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1983 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

NINETY-SEVENTH CONGRESS

SECOND SESSION

ON

H.R. 5842

FEBRUARY 23, 25; MARCH 4, 1982

[No. 108]

Printed for the use of the
Committee on Science and Technology

U.S. GOVERNMENT PRINTING OFFICE
96-331 O WASHINGTON : 1982

H701-77

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*On assignment to Budget Committee for 97th Congress.

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1983 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

TUESDAY, FEBRUARY 23, 1982

House of Representatives,
Committee on Science and Technology,
Subcommittee on Science, Research and Technology,
Washington, D.C.

The subcommittee met, pursuant to notice, at 1:10 p.m., in room 2318, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Present: Representatives Walgren, Shamansky, Brown, Lundine, Skeen, Gregg, and Weber.

Mr. **Walgren**. Let me call our meeting to order and welcome our witnesses.

Today marks the beginning of the annual authorization hearings to consider the fiscal 1983 budget for the National Science Foundation. The Foundation, represented by the Director, Dr. Slaughter, will be providing us with an overview as well as focusing on a number of their important activities, particularly today in biological, behavioral, and social sciences and the science, technology, and international affairs directorates.

Before turning to Dr. Slaughter and the representatives of the Foundation, I would like to say personally that there are some positive aspects and also some negative aspects to the administration's present position with respect to the National Science Foundation.

I think we all agree that the overall budget being requested appears to be fairly reasonable. That is certainly in contrast, in my personal opinion, to what was sought last year by the administration. I think it is fair to say that some of the research functions have fared relatively well as we look at what the administration is proposing.

There is one very major exception, and that exception is the science and engineering education directorate. The education activities of the National Science Foundation are now reduced over 81 percent since 1981, and they would be reduced 30 percent in this year's request from current spending levels. This comes at a time when every considered judgment, in my opinion, is telling the committee that we as a country have major problems regarding our technical, engineering, and science manpower needs.

What is more difficult for me to understand is the decision of the Foundation to eliminate the directorate which had traditional responsibility for science education. It strikes me that this coming at this time, while the directorate still has a number of functions to perform under the present budget that the Congress provided the Foundation—elimination of that directorate and the programed reduction in staff of more than three-quarters could only be characterized as something akin to a preemptive strike on that function.

It was not too long ago that education was over one-half of the total NSF budget, as I understand it, and the organic act of the Foundation itself specifically gives the National Science Foundation the responsibility for—in the words of the act—the well-being of scientific and technical research and education.

It is very disturbing to me as one Member—and I am not alone in that disturbance—that we should see this kind of undercutting of the science education function even before the year is out and the Congress has not even had an opportunity to express its will about what the budget will look like next year.

With that having been said, our hearing today will turn to other matters, but on Thursday we will focus particularly on science education. I know it is going to be a matter of some major importance to the committee.

After hearing from Dr. Slaughter, we will turn to the other witnesses who will speak on a number of issues and activities of the Foundation. These include the intergovernmental and international activities of the STIA directorate and the social and behavioral activities of the biological and behavioral science directorate.

Since we covered a number of these concerns in last year's hearings, I would like to insert into the record at the end of my statement a summary of our findings and testimony from last year as well as a report from the General Accountng Office showing the impact of the budget changes on general individual actuaries.

I would note, regarding the international activities, that this administration has raised a new issue, one of national security. This is rather disturbing, with implications that go well beyond the budgetary matters that we are typically focused on and are discussing today. I know that all the members of the committee will look forward to hearing more on that subject.

[Material to be supplied follows:]

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SUMMARY OF TESTIMONY ON BEHAVIORAL AND SOCIAL SCIENCES (BASED ON HOUSE HEARINGS ON FISCAL YEAR 1982 NATIONAL SCIENCE FOUNDATION AUTHORIZATION ACT, HELD MARCH 12, 1981)

Genevieve J. Knezo
Specialist, Science and Technology
Science Policy Research Division
February 10, 1982

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SUMMARY OF TESTIMONY ON THE BEHAVIORAL AND SOCIAL SCIENCES, pp. 525-682 [1]

The Subcommittee on Science, Research, and Technology devoted one day to hearing testimony on the behavioral, social, and economic sciences. Testimony were heard from:

- Dr. John B. Slaughter, Director, National Science Foundation,
- Dr. Lawrence R. Klein, professor of economics and finance, University of Pennsylvania, and Nobel Laureate in economics, 1980,
- Dr. Zvi Griliches, chairman of the Economics Department, Harvard,
- Dr. Kenneth Prewitt, president, Social Science Research Council, and chairman, Political Science Department, University of Chicago,
- Dr. Henry W. Riecken, professor of behavioral Science, University of Pennsylvania, and
- Dr. David C. Glass, professor of psychology, City University of New York and president, Academy of Behavioral Medicine Research.

Statements were submitted by:

- Dr. David Hamburg, Division of Health Policy Research and Education, Harvard University,
- Dr. Harvey Brooks, Division of Applied Sciences, Harvard University,
- Dr. F. Thomas Juster, director, Institute for Social Research and professor of economics, University of Michigan,
- Dr. Ralph Andreano, professor and chairman, Department of Economics, University of Wisconsin, and
- The Association for the Advancement of Psychology and The American Psychological Association.

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[1] U.S. Congress. House. Committee on Science and Technology. Subcommittee on Science, Research, and Technology. 1982 National Science Foundation Authorization. Hearings. Jan and Mar. 1931. 97th Congress, first session. Washington, U.S. Govt. Print. Off., 1981.

A. INTRODUCTION TO CUTS PROPOSED FOR BEHAVIORAL AND SOCIAL SCIENCES IN THE FISCAL YEAR 1982 NATIONAL SCIENCE FOUNDATION BUDGET

The Administration's fiscal year 1982 budget had preserved core support for basic research in the biological and physical sciences, but proposed major reductions in funding for the behavioral and social sciences in the Biological, Behavioral and Social Sciences Directorate of the National Science Foundation (NSF). In comparison with pre-recission fiscal year 1981 expenditure plans, the cuts, according to the Subcommittee Chairman Doug Walgren, were 26 percent from the behavioral and neural sciences (divided as follows: neurosciences, 8 percent increase, cognitive and behavioral sciences, 60 percent decrease, and anthropology, 33 percent decrease); and social and economic sciences, 70 percent decrease. 2 / A recission was proposed for FY1981, consisting of a $10 million cut in social and economic sciences, and a $5 million cut for behavioral sciences. 3 / Dr. Eloise Clark, Assistant Director for Biological, Behavioral, and Social Sciences, testified that the cuts would compel NSF to renegotiate with grantees to reduce costs on individual grants already awarded and would permit only few, if any, new awards in some other areas. 4 /

B. COMMITTEE MEMBERS' OBJECTIONS TO THE CUTS

Many witnesses and Committee members objected to these cuts. Congressman Doug Walgren opened the hearings by underscoring the incongruity between the cuts and pressing societal information needs:

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2 / Hearings, Ibid., p. 573.

3 / Ibid., p. 581.

4 / Ibid., p. 581.

> It has been said that the 1960s and 1970s were the period of major physical sciences and technological advances, while the 1980s should be the decade of the biological and social sciences.

Striking a note echoed by most other witnesses, he emphasized that behavioral and social sciences knowledge was needed especially to solve major economic problems of the decade: transferring technology to the marketplace, industrial innovation and productivity, and assessment of the societal effects of Government actions. Congressman George Brown's major concern was the Administration's apparent unwitting ignorance of the long-lead time needed to develop knowledge in this area and the long-term importance of knowledge improvements and their potential effect ". . . upon the major national problems that face the country." 5/ Congressman Vin Weber said that the Administration's scientific priorities seemed imbalanced:

> . . . [W]e have gone through a period of substantial investment and advancement in physical and biological sciences, and that indeed there may be a reason why the priority of behavioral and social sciences in the future is even greater than in the past. That . . . is directly contradictory to the direction that the administration has proposed. . . . 6/

Congressman Bob Shamansky sounded another theme -- the "contradition" between the President's apparent extensive use of social and economic sciences and the Administration's cuts in social and behavioral research, which, it was said, were of lower priority than other areas of science:

> If I remember President Reagan's [State of the Union] speech on February 18, [1981] he pointed out that he had been advised by some very fine economists in preparing his approach in this

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5/ Ibid., p. 573.

6/ Ibid., p. 577.

> message. Given the fact that economics could be discredited in these terms here as a soft science, I am a little concerned that the soft sciences seem to be eliminiated substantially from the funding.

The Congressman added that such cuts cast doubt on the integrity of the President's speech. 7 /

C. NSF DIRECTOR DESCRIBED THE ADMINISTRATION'S RATIONALE FOR THE CUTS AND HIS DIFFERENCES WITH THESE DECISIONS

The NSF budget was reduced in accord with a need to cut overall Federal spending, according to Dr. John Slaughter, NSF Director. Cuts were made in the behavioral and social sciences specifically ". . . to reduce overall Foundation spending planned in areas perceived to be of lower priority." 8 / Congressman Walgren pointed out the disparity between the size of the cuts in the behavioral and social sciences and the higher funding levels for other disciplines when he asked Dr. Slaughter "You are now unable to fund even the highest priority in the behavioral sciences, even though you are able to fund the lowest priority in another area, is that correct?" Dr. Slaughter replied it was, but that accounts were not transferable. 9 / He added that despite the cuts, he expected NSF ". . . to maintain a significant program of research in the social sciences disciplines." 10/ The cuts would not foreclose all new initiatives, but would force limits on the number of new proposals that could be accepted. 11/ Dr. Slaughter said that the cuts would not eliminate

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7 / Ibid., p. 582.

8 / Ibid., p. 526.

9 / Ibid., p. 580.

10/ Ibid., p. 526.

11/ Ibid., p. 576.

any programs of support and hoped that the Foundation could ". . . put a strong program before you next year." 12/ NSF support is critical since its builds the infrastructure]longitudinal databases, scientific personnel, research procedures, etc.] needed to develop a science. Discontinuities resulting from massive cuts would be hard to overcome. The Director emphasized that the role of the NSF is especially critical for the social sciences since only ". . . 20 to 30 percent of the proposals received in these fields are funded [and] at 75 percent or less of the funds requested." 13/

OMB targeted the cuts made specifically in the behavioral and social sciences, according to Dr. Slaughter. But he said that if OMB had given him the opportunity to make cuts in the NSF program, he would not have made the same eliminations and reductions that OMB made. 14/ He testified:

> The social and behavioral sciences play a key, and in some cases preeminent, role in some of the critical problems facing the country. The enormous challenge facing the Foundation and the scientific community particularly concerned with the social and behavioral sciences demonstrates [the] point conclusively. We must strengthen the role of the behavioral and social sciences within the Foundation and strengthen the support to the scientific community in the future. 15/

D. OMB DID NOT CONSULT THE SCIENTIFIC COMMUNITY WHEN MAKING CUTS

It was noted several times during the hearing that OMB apparently did not consult scientists either within NSF or in the community outside about where cuts should be made. Dr. Ernestine Friedl, a member of the National Science Board said that the Board had not been consulted because of the timing of

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12/ Ibid., p. 582.

13/ Ibid., p. 528.

14/ Ibid., p. 574.

15/ Ibid., p. 577.

the OMB decision. The Board's budget-making responsibilities for fiscal year 1982 were already completed when the transition team and the Reagan OMB were working on budget cuts. She added that the Board would devote considerable energy to examining NSF's future support responsibilities in the social and behavioral sciences. 16/

Dr. James Fletcher, former NASA administrator and a member of President Reagan's transition team that looked at science funding, also criticized the cuts proposed in social and behavioral sciences -- which he said ". . . seems to be unreasonably curtailed, probably as a result of the earlier difficulties with this program. . . . The Social and Behavioral Sciences ought to be funded at a level comparable to last year to provide proper continuity of funding for researchers in this field." 17/

E. IDEOLOGICAL MOTIVES ATTRIBUTED TO CUTS

Some witnesses attributed several motivations, other than spending reductions, to the cuts. Congressman Brown noted that it is not uncommon to hear some in the Administration and in Congress say that social and behavioral sciences were not needed as a science since political leaders generate common sense "social information" by virtue of their activities and discussions. 18/

Some said the Administration's cuts appeared to be ideologically motivated. Dr. Zvi Griliches, Chairman of the Economics Department at Harvard University, testified that ". . . motivation for these specifically targeted cuts appears to be based on vindictiveness, arrogance, and ignorance. . . ." 19/ In the

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16/ Ibid., p. 529.

17/ Ibid., p. 734.

18/ Ibid. p. 575.

19/ Ibid., p. 587.

economics area for instance, ". . . many of the more extreme new [Reagan Administration] economic proposals have found little support among established scientists. Because they have not flocked to support them, they are perceived as being captives of liberal left-wing ideologues." 20/

Addressing a similar issue, Dr. Harvey Brooks, a physical scientist and writer in science policy, said:

> Although any budgetary process is inevitably politicized in some measure, I believe the allocation of money for science is less politicized than most of the budgtary process. It has been a careful and considered process that has engaged some of our best minds and our most thoughtful people, and in consequence it seems dangerous to reject the outcome of this process by drastically cutting out selected parts of the program for reasons which, if press reports are to be believed, amount to little more than personal prejudice and hearsay on the part of a very small number of officials with no knowledge of the long background of thought and planning which has brought us to where we are today. To select the social and economic sciences for a 75 percent budget slash in a single year can only be characterized as foolhardy in my opinion. 21/

F. HISTORY AND OBJECTIVES OF NSF SUPPORT FOR BEHAVIORAL AND SOCIAL RESEARCH

Dr. Slaughter gave the Subcommittee a short history of NSF support and priorities in the behavioral and social sciences disciplines. He traced the difficult history of support for social sciences in NSF. Congress was skeptical about supporting such research when NSF was first created and, although the Foundation cautiously supported social sciences from its earliest years, it was not until 1968 that Congress amended the NSF Organic Act to include social sciences explicitly as a discipline for which research support should be provided.

20/ Ibid., p. 590.

21/ Ibid., p. 646.

NSF plays a unique role among Federal agencies in supporting research on "human behavior and operations of society," that is, of "fundamental theoretical or empirical interest, not tied to a mission activity." 22/ NSF-supported research, Slaughter said, is not intended to prove or disprove a particular position regarding social policies or actions. 23/ Whether basic or applied, NSF-supported social research is intended to be a source for objective analyses, which produces knowledge of general and lasting value. Slaughter emphasized that "rarely has [NSF] funding [for social and psychological research] exceeded more than five percent of NSF's budget. [But] the importance of our presence in these fields is substantial far beyond the absolute sums involved. For some disciplines the Foundation is the only source of support for investigator-initiated, university-based research."

G. DR. SLAUGHTER AND OTHERS IDENTIFIED AREAS WHERE RESEARCH FUNDING IS NEEDED

Many witnesses cited areas of research ripe for investigation but lacking research resources. Dr. Slaughter inserted a background paper citing achievements of NSF behavioral and social research programs over the years and also areas of research support that would be affected by the cuts. 24/ Among the research areas which would suffer cuts were: economics, including promising areas of theory and models of supply-side economics and consumer behavior; database development, including maintaining and permitting access to ". . . bodies of high-quality data upon which social and behavioral theories are formed, tested, and revised in light of verifiable evidence," the development

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22/ Ibid., p. 527.

23/ Ibid., p. 533.

24/ Ibid., pp. 539-572.

of major software for use of archival data, important activities like the Center for Research on the Coordination of Social Indicators, and support for conferences on the development and use of Government-generated social data; organizational research; studies in governance; research in the philosophy of science; and anthropological investigations. The consensus was that there probably would be a halt in the the momentum toward discovery and accumulation of knowledge generated by a series of successive NSF awards, each building upon its predecessors.

Many witnesses cited social problem areas whose solution required the kind of knowledge and understanding generated by behavioral and social science research. Dr. Slaughter cited a few: long-term solutions to the energy shortage, productivity, processes of innovation. 25/ Congressman Brown, referring to a study he had just had translated from Japanese, said behavioral/social research is needed to determine why the Japanese succeed in developing technologies and penetrating foreign markets. The study he read pointed to a greater appreciation by the Japanese, than by their competitors, of the combination of values and technology that drive market forces. Americans, Mr. Brown added, do not seem to have fully appreciated the need to understand values which guide consumer and investment choices. 26/

H. VIEWS OF ECONOMISTS

1. Dr. Lawrence Klein Cites NSF Support for Nobel Prize Research

Dr. Lawrence Klein, a Nobel Laureate in economics, testified that during the 1970s, when private foundations started cutting back on support

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25/ Ibid., p. 535.

26/ Ibid., p. 578.

for social research, NSF funded the econometrics studies for which he is lauded. Over $100 million worth of market activity is generated annually by the fruits of his research: statistical models resulting in systems used by banks, international agencies and Federal, State, and local governments. He and other witnesses said that cuts in economic sciences research in NSF would effectively end social scientists' major source of objective support ". . . unencumbered by contractural obligations. . . ." and would seriously challenge "free thinking and the generation of new ideas, especially by younger scholars."27/ Klein listed critical social problem whose understanding would suffer without additional research support. These included: financing social security, coping with stagflation, standarizing the exchange value of the dollar, designing a world monetary system, and preserving exhaustible resources. Development of data bases and methodology would also suffer, as would the training of new professional economists. He also said that scientists, not bureaucrats, should make decisions on cuts, since" . . . the scientists are in a better position to know what is promising and what is not." 28/

2. Dr. Zvi Griliches Testified That the Administration's Economic Theories Are Based on NSF-Supported Economics Research, Which Should Be Continued

Several economists present attributed the origins of the Reagan Administration's economic ideas to NSF-supported research. Dr. Zvi Griliches described how the bulk of the Administration's economic program is based upon NSF-funded research:

> It is ironic. . . that most of the recent conservative ideas in economics -- the importance of rational expectations and the impotency of conventional macroeconomic policy, the disincentive effects of

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27/ Ibid., p. 584.

28/ Ibid., p. 586.

> various income-support programs, the magnitude of the regulatory burden -- all originated in or were provided with quantitative backing by NSF supported studies. 29/

He made a vigorous argument for social and economics science research support especially by the Reagan Administration:

> The country is embarking on one of the largest macro-economic policy experiments in our history with very little research support for it, and they do not even want to know how to measure its effect, how it is going, what its consequences might be. 30/

Griliches cited specific economic sciences research topics, relevant to understanding the Reagan Administration's economic policies, which warranted funding. These included responses of individuals to various tax, subsidy, and retirement schemes based on analysis of newly collected survey data and his own studies of the differential effects over time of product development and market activity caused by varying patterns of R and D expenditures in different types of firms. 31/

> For example, the Census Bureau is putting together currently under my direction and with NSF financing the data it has collected in annual surveys on R and D expenditures -- from company R and D expenditures. These data are collected annually but have never been put together so that one can follow the expenditures over time of individual firms. What we're trying to do is to format them so that one can follow the futures of individual companies and see how and when R and D paid off. This involves a data base of about 1,000 companies for 20 years with 10 to 50 variables measured for each firm in each year. To match, clean, access, and analyze such data is a major task. It involves processing over half a million of different numbers.

29/ Ibid., p. 590.

30/ Ibid., p. 590.

31/ Ibid., p. 589.

> This work is worth doing. . . but it cannot be done without significant computer and research resources. It is this kind of work that won't get done if these cuts are sustained. 32/

Griliches concluded that "What I'm afraid of, and what I would like you to stop, is the dismantling of the whole economic research enterprise. . . . Moreover, we may lose a whole generation of economic analysts." 33/

3. Dr. David Grove Cited Value of Economics Research to Policymakers

Dr. David Grove, president of the U.S. Council of the International Chamber of Commerce, also said this Administration, in particular, needed to use the knowledge generated by economics research. "My reason can be stated quite simply," he said and continued:

> Congress and the new Administration currently are undertaking a restructuring of our national priorities, and are searching for more effective ways to achieve our national goals. If we are to be successful in these endeavors, we shall need to know as much as humanly possible about how our economy operates, and how we can both measure and diagnose our successes and our failures. 34/

Like Dr. Griliches, he also identified economic tools and techniques in widespread use in business and Government, which had been developed with NSF support, in particular the GNP, National Income, and Flow-of-Funds Accounts. Basic research, he said, is needed to provide knowledge to assist in implementing and evaluating supply-side economic policies and policies being proposed to raise the growth of national productivity. He concluded:

> Cutting the financial support of the National Science Foundation for basic economic research at this time would seriously retard the progress we need to make if public policy is to be determined increasingly by knowledge rather than by rhetoric and special pleading which have little or no underlying factual or analytical

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32/ Ibid., p. 589.

33/ Ibid., p. 590.

34/ Ibid., p. 680.

> base. Any such fiscal "savings" would be false economy indeed, with very costly long-term consequences.

Dr. Ralph Andreano professor at the University of Wisconsin also identified areas of economics research which require NSF funding. 35/

I. TESTIMONY ON SOCIAL SCIENCES BY DR. KENNETH PREWITT

Dr. Kenneth Prewitt, President of the Social Science Research Council and professor on leave from the Political Science Department, University of Chicago, testified that cuts in the NSF programs (which were accompanied by massive cuts in behavioral and social sciences research funding programs in other agencies) signalled the dismantling of the behavioral and social sciences as sciences since their research infrastructure would be indelibly altered:

> The proposed reduction in the NSF budget, when coupled with the reductions at the National Institute of Mental Health and the National Endowment for the Humanities, is analgous to taking radio telescopes away from astronomers, animal laboratories away from biologists, linear accelerators away from physicists. 36/

1. Dr. Prewitt Summarized History of Social Science Accomplishments

Dr. Prewitt said that "For 50 years the social sciences have concentrated a large share of their research resources and intellectual attention on the issues which have been of deepest concern to this society." He traced some of the notable hallmarks of social research in part to demonstrate their accomplishments. He started with the preparation of Recent Social Trends, requested by President Hoover in the 1920s to describe facets of society affected by World War I and the depression. Social science research on the

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35/ Ibid., pp. 666-667.

36/ Ibid., p. 606.

depression during the 1930s generated national, State, and local statistical systems in use today. War-related research during the 1940s dealt with recruitment, training, management, and discharge of member of the Armed Forces. The point system used to discharge soldiers and the GI Bill of Rights were the result of a study, The American Soldier. Foreign area studies occupied attention in the 1950s. The 1960s were marked by studies of race relations, urban policy, and development of the policy sciences. Three topics serve as hallmarks of social and behavioral research in the 1970s: concern about the unintended conseqeunces of Government efforts to regulate economic and social activities, evaluation research, and behavioral medicine.

Like other witnesses, Prewitt anticipated that social science research would make notable contributions to issues of economic recovery in the 1980s:

> What can we expect of the 1980s? If economic productivity, industrial revitalization, social innovation, and decentralization are issues on the agenda, there will be serious and sustained attention to these matters by some of the best social scientists in the country . . . . Indeed, the work is already underway. In the current issue of Scientific American the lead article presents, in human capital terms, an innovative way to look at the place of the service sector in the economic productivity of the United States. In a recent issue of Science, the lead article reports research on the conditions which transform a scientific innovation into practical advances in weaponry or biomedical therapies. This research, on the pay-off of different forms of research and development, goes straight to the issue of innovation and productivity. 37/

2. Social Science Is Erroneously Identified With Social Policy

An erroneous link between the social sciences and social policy began in the 1960s, Prewitt said. He continued "Persons who opposed the policies, especially the Great Society programs of President Johnson, have sometimes

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37/ Ibid., p. 618.

opposed not just the policies but also the social sciences methods and concepts applied in the policy process. This confuses the science with the social program and grants to social science much more influence than it had or will ever have."38/ But social science does not determine policy, it only informs decisionmakers who make policy using "an exercise in moral choice and political judgment." Likewise, he said, when social science contributes to effective policy or programs, often "the credit is claimed by the political process and is not shared with the social science responsible for the demographic projection, the economic indicator, the sociological concepts or the organizational analyses found useful." This leads to ". . .a systematic under-appreciation of social science research." 39/

J. DR. HENRY W. RIECKEN CHARACTERIZED THE SCIENTIFIC NATURE OF SOCIAL AND BEHAVIORAL SCIENCE

Dr. Henry W. Riecken, a past president of the Social Science Research Council and now Professor of Behavioral Science at the School of Medicine, continued the theme sounded by Dr. Prewitt that the social sciences were misunderstood. He began his testimony by describing the methodological equivalence of the sciences:

> . . . Most behavioral and social scientists spend most of their time doing exactly what other kinds of scientsits do -- namely, making observations and measurements -- and a lot of effort has gone into improving the measurement of behavioral and social phenomena. A lot more is still needed, since the phenomena are complicated and complexly determined. 40/

38/ Ibid., p. 608.

39/ Ibid., p. 608.

40/ Ibid., p. 621.

Furthermore, he said that often people "find it difficult to believe that there is a science of behavior. . . " precisely because the ". . . behavioral sciences deal with phenomena that, unlike astronomy or microbiology, are well within everyday experience, so everybody can, in some sense, consider himself to be an expert, an experienced observer of human behavior."

1. Contributions of Behavioral and Social Technology

But the theory and methodology that behavioral scientists bring to observing human behavior can lead to fundamental developments in behavioral and social technology. He cited three examples. The first was the potential saving of abused children's lives by development of a scale to assess high-risk, potentially life-threatening cases of child abuse for use by overworked and understaffed social welfare agencies who cannot afford to devote equal time to all cases of child abuse and need to perform triage to prevent deaths. The second was the construction of a behavioral profile of potential plane hijackers for the Federal Aviation Administration. The third example he cited was use of a pscyhological test to distinguish whether people would be equally affected or debilitated by influenza virus.

Riecken's description of the usefulness of the social sciences extended to the legislative branch itself. Techniques of program evaluation, developed largely by sociologists, psychologists, and economists, in the 1960s and 1970s have been formally incorporated into the procedures of the Congress by virtue of the passage of the Congressional Budget Act of 1974 and the subsequent creation of the Institute for Program Evaluation at the General Accounting Office, staffed largely by social scientists. Riecken closed his testimony by citing the importance of behavioral research to the future and safety of the nuclear power industry in the United States. In an article in

Technology Review, Dr. John Kemeny, president of Dartmouth, a mathematician, and chairman of the Presidential Commission To Investigate the Nuclear Powerplant Accident at Three Mile Island said:

> We started our work with the prior conviction that the big problem was equipment. But our overwhelming conclusion was that the basic equipment was amazingly good; it was the control room that was terribly designed from the point of view of the people who had to use it. The Commission's attention slowly but steadily shifted, almost completely, from equipment to people. We found that this was one of the most horrendous people problems we had ever encountered. [41]

2. Contributions Identified by Psychologists

The Association for the Advancement of Psychology and the American Psychological Association inserted a statement for the record which described additional contributions of behavioral research results:

- psychological rsearch on human perception and psychophysics, which led to the identification of a visual illusion which occurred during night flight landings,
- study of basic psychophysiological mechanisms underlying taste, which led to methods of predator control,
- research on personnel selection, which produced improved methods of employee selection and job productivity, and
- basic behavioral research, which led to understanding and perfecting techniques of biofeedback.

K. THE CROSS-FERTILIZATION OF BEHAVIORAL RESEARCH AND MEDICAL RESEARCH

1. Dr. David Glass

Several witnesses discussed the specific contributions of behavioral and social research to medical research and therapy. Dr. David Glass, Professor of psychology and director of the Laboratory of Biobehavior, Graduate Center City University of New York, and President, Academy of Behavioral Medicine Research, discussed the causative effects of psychosocial factors on cardiovascular disease. He said that several decades of epidemiological research identified many of the risk factors for coronary heart disease, but these accounted for less than 50 percent of new cases. Subsequent research by behavioral scientists identified that job-related and other kinds of stress, certain life styles, and patterns of coping correlate directly with the onset of coronary heart disease. He also described a new research field, called psychoneuroimmunology. Stradling the behavioral sciences and medicine, it studies interrelationships between the central nervous system, and endocrine, behvioral and immunologic responses. Many of these developments, he added, were described in the NSF-prepared Five-Year Outlook in Science and Technology. Glass concluded that solving major health problems of the Nation requires more social and behavioral research, data, and trained investigators -- goals which would be compromised by funding cutbacks:

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[41] Ibid., p. 625.

> . . . Research that explores the mechanisms integrating behavioral and biological processes . . . should be fostered. We are in dire need of investigators who are jointly trained in the biobehavioral disciplines. This demands increased science training, increased pre- and post-doctoral fellowships. 42/

2. Dr. David A. Hamburg

On a related issue, Dr. David A. Hamburg formerly president of the Institute of Medicine and now director of the Division of Health Policy Research and Education, Harvard University, wrote to the chairman of the

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42/Ibid., p. 641.

House Subcommittee on Science, Research, and Technology that medical knowledge sometimes is based upon behavioral science knowledge:

> You will note that the biobehavioral and social sciences have an important place in this analysis. For example, advances in cardiovascular disease, some forms of cancer and mental illness depend heavily on advances in the scientific understanding of human behavior. The fund of knowledge from which health applications can be drawn is based in large part on fundamental research supported by the National Science Foundation. 43/

L. DR. HARVEY BROOKS COMMENTED ON CONTRIBUTIONS OF THE SOCIAL SCIENCES TO TECHNOLOGICAL APPLICATIONS

Dr. Harvey Brooks, a physicist, who is a professor of technology and public policy at Harvard, discussed the contributions of social and behavioral sciences to technology and the understanding of its applications. Brooks wrote that

> . . . a large part of the superior economic performance of the Japanese is not the result of superior innovation in the technological sphere, but rather the result of superior organization and managerial techniques which are more respectful of the motivations and perceptions of people. Most of the Japanese successes have been based on more effective use of American technology. Perhaps this success was due more to the fortunate concatenation of cultural circumstances that any conscious superior use of social knowledge or insight; I would not want to pretend that the Japanese miracle is attributable to their better support of or use of social science knowledge. Nevertheless, it may take social science knowledge for us to understand the sources of Japanese success, and to determine what aspects of it are applicable in the sharply different American culture and traditions. The whole virtue of science, after all, is that, properly applied, it enables us to learn from the successes of others without having to imitate blindly and gradually discover by trial and error what works and doesn't work in our circumstances. When we understand why things work or don't work we are not condemned to retrace the entire learning processes of the pioneers. 44/

Brooks also cited the potential contributions of social research to alleviating some of the burdens caused by industry's need to anticipate regulatory actions

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43/ Ibid., p. 644.

44/ Ibid., pp. 647-8.

and to hastening innovation and the accumulation of long-term profits. He called for a restoration of governmental funding of social research. 45/

M. IMPACTS OF CUTS ON SOCIAL SCIENCE DATA ARCHIEVES

Several witnesses asserted that cutbacks in NSF support for social research would cause severe strains in the maintenance and continuation of social science data archives, most of which had been funded largely by NSF. Dr. F. Thomas Juster, Director of the Institute for Social Research at the University of Michigan, a major repository of social science data archives used by social scientists throughout the country, made the most striking statement in this regard. He said in part:

> . . . Unlike the physical sciences, where the data are almost always generated by researchers and guided by theory, social science data are often generated by the administrative needs of the nonscientific world (the receipts, payrolls, tax payments or inventories of business firms, the enumeration of the population in the Census, the invoices collected for export or import recording purposes, etc.) or by the administrative or intelligence needs of governments. . . . These types of data are enormously useful for analysis of a great many types of economic and social phenomena. But they are an imperfect substitute for data tailored to the needs of social science researchers, guided by the concepts and theories of their disciplines . . . .
>
> The generation of nationwide social science data is expensive . . . . In the social sciences, the cross-sectional and longitudinal surveys that provide data on both households and business establishments also require investments of public funds that are large relative to available resources. . . . A budget cut for NSF supported social sciences of the recommended size would almost certainly eliminate most large-scale scientific data collection. Whatever the past successes or failures of the social sciences, virtual elimination of the data bases generated by social scientists for research purposes would guarantee a retardation in the rate of knowledge growth about society. A decade from now, both the Congress and the Administration would regret that decision. 46/

45/ Ibid., p. 649.

46/ Ibid., pp. 664-665.

Juster also predicted future social problems whose understanding will require massive amounts of data. These include two major implications of demographic shifts: growing numbers of older people (with implications for the health care industry, the housing industry, and family structure), and population shifts to the sunbelt, with associated demands on service delivery.

TABLE 1. Trends in Conduct of [Federal] R and D,
Selected Years, Current and Constant Dollars
(Obligations in Billions of Dollars) 1/

Year	Defense 2/	All Other	Total
1972	$ 8.9	$ 7.6	$ 16.5
1975			
Current $	9.7	9.3	19.0
Constant 1972 $	7.88	7.55	15.43
1979			
Current $	13.6	15.4	29.0
Constant 1972 $	8.35	9.46	17.81
1980			
Current $	15.1	16.6	31.7
Constant 1972 $	8.5	9.39	17.94
1981			
Current $	17.8	17.2	35.0
Constant $	9.19	8.88	18.08
1982, est.			
Current $	22.1	16.8	38.8
Constant 1972 $	10.56	8.03	18.5
1983, est.			
Current $	26.2	16.8	43.0
Constant 1972 $	11.75	7.53	19.29

1/ Deflators supplied by NSF are:

1975: 1.231; 1979: 1.628; 1980: 1.767; 1981: 1.935; 1982: 2.093; 1983: 2.229.

Current dollars data are taken from Table K-9, "Trends in Conduct of R&D," *In* U.S. Off. of Management and Budget. Special Analysis K, Research and Development, Budget, 1983. Feb. 1982, p. 29.

2/ According to source, this includes military-related R&D programs of the Depts. of Defense and Commerce [energy].

TABLE 2. Trends in Federal Funding for Basic Research, FY 1981 to FY 1983, Current and Constant Dollars, Defense and Civilian Outlays (Millions of Dollars) 1/

	FY 1981, est.		FY 1982, est.		FY 1983 est.		Percent Change in Constant 1972 Dollars Between FY 1981 and FY 1983
	Constant 1972 $	Current $	Constant 1972 $	Current $	Constant 1972 $	Current $	
Defense-Military	286.3	712	294.3	616	319.4	712	+11.56%
Civilian = (Total minus Defense-Military)	2,284.75	4,975	2,55.61	4,721	2,181.24	4,862	-4.53%

1/ Deflators supplied by NSF are:

1981: 1.935; 1982: 2.093; 1983: 2.229.

Current dollars data taken from Table K-3, "Conduct of Basic Research By Major Departments and Agencies," *In* U.S. Off. of Management and Budget. Special Analysis K, Research and Development, Budget, 1983. Feb. 1982, p. 7.

TABLE 3. Trends in Funding for Applied Research and Development, Military/Defense and Civilian, FY 1981 to FY 1983, Current and Constant Dollars, Outlays (Millions of Dollars) 1/

	FY 1981, est.		FY 1982, est.		FY 1983, est.		Percentage Change in Constant 1972 Dollars Between 1981 and 1983
	Constant 1972 $	Current $	Constant 1972 $	Current $	Constant 1972 $	Current $	
Total Federal Funding for Applied Research and Development 2/	15,130	29,277	15,331	32,088	15,948	35,548	+5.4%
Total Federal Funding for Defense-Military Applied Research and Development	7,838	15,166	8,680	18,168	9,852	21,961	+25.7%
Total Federal Funding for Civilian Applied Research and Development 3/	7,292	14,111	6,651	13,920	6,096	13,587	-16.4%

1/ Deflator factors supplied by NSF are: 1981: 1.935; 1982: 2.093; 1983: 2.229. Current dollars data are computed from Table K-3, "Conduct of Basic Research by Major Departments and Agencies," p. 7, and Table K-2, "Conduct of Research and Budget. Special Analysis K, Research and Development, p.5, *In* U.S. Off. of Management and Budget. Special Analysis K, Research and Development, Budget, 1983. Feb. 1982.

2/ Appropriate data from Table K-3 were subtracted from Table K-2. It is assumed funding for facilities is not included.

3/ The component Defense/Military in both tables was subtracted from the total to give a figure for "civilian."

UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

PROGRAM ANALYSIS
DIVISION

January 26, 1982

Same for
NSF Authoriz
Record.

B-206166

The Honorable Doug Walgren
Chairman, Science, Research
and Technology Subcommittee
Committee on Science and
Technology
House of Representatives

Dear Mr. Chairman:

Subject: Impact of Budget Cuts on Three
Directorates of the National
Science Foundation (PAD-82-25)

In your letter of November 12, 1981 (see Enclosure I), you requested that the General Accounting Office provide information on the effect of recent cuts in certain areas of the National Science Foundation (NSF) budget. Specifically, you requested information on the impact of the cuts as they apply to three NSF directorates: Science and Engineering Education; Biological, Behavioral, and Social Sciences; and Scientific, Technological, and International Affairs. The short timeframe involved in responding to your request precluded an extensive or indepth analysis leading to judgments as to the extent of effects in areas that cannot be easily quantified.

Our evaluation was conducted at NSF in Washington, D.C. We reviewed various NSF budget documents and records pertaining to planned expenditures for fiscal years 1980, 1981, and 1982. We interviewed 26 NSF officials in the three directorates, the Division of Budget and Program Analysis, and the Office of Government and Public Programs. We converted budget figures to constant fiscal year 1980 dollars using GNP implicit price deflators which were obtained from NSF's Science Resources Studies group. These figures were derived from reports from the U.S. Department of Commerce's Bureau of Economic Analysis.

Enclosure II is a table comparing NSF funding for fiscal years 1980 through 1982 in both current and constant dollars. Fiscal year 1982 data is based on a projection of the budgeted rate of obligation for the first quarter of the fiscal year and is used to show what the impact would be if that rate of obligation were experienced throughout the remainder of the fiscal year. Enclosures III through V provide similar information for each of the three directorates included in your request. In

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addition, these enclosures provide data on personnel, continuity of ongoing research, and program changes. The information was provided to us by NSF officials. Because of the short timeframe for completion of our work, we were not able to verify the accuracy of the data. Enclosures III through V also provide information on opinions of NSF staff, including their views on the effect of NSF's funding cuts on the communities and objectives they serve. This information has not been verified and does not necessarily represent an agency position on the subjects addressed. Enclosure III covers the Science and Engineering Education Directorate; Enclosure IV, the Biological, Behavioral, and Social Sciences Directorate; and Enclosure V the Scientific, Technological, and International Affairs Directorate.

After we completed our work, NSF's appropriation for fiscal year 1982 was passed with the enactment of P.L. 97-101 on December 23, 1981. This Act appropriated a greater amount than the projection of the first quarter obligation rate on which our work is based. We based our work on the projected annual funding level of $909.5 million. The appropriation passed December 23 provides total funding to NSF of $1,035.1 million. NSF officials have informed us that information on the allocation of the appropriation to NSF's directorates and programs will not be available until the President submits his fiscal year 1983 budget in February. Depending on how the appropriation is allocated, the increased funding will modify the planned reductions of personnel, the funds available for grants, and the impact of reductions in the three directorates.

EFFECT OF FUNDING CUTS ON THE THREE DIRECTORATES

Based on first quarter fiscal year 1982 planned expenditure rates, the programs affected the most were in the following areas of the three directorates. In the Science and Engineering Education Directorate, all science and engineering education programs would be eliminated except for graduate fellowships. In the Biological, Behavioral, and Social Sciences Directorate, substantial cutbacks would occur in the social, economic, cognitive, and anthropological sciences. In the Scientific, Technological, and International Affairs Directorate, reductions would take place in almost all the Directorate's programs. Support to State and local governments would be sharply curtailed and some programs such as the Appropriate Technology, University Based Innovation Centers and State Science and Engineering Technologies programs would be totally eliminated.

As of December 31, 1981, no reductions in force have taken place in the three directorates. However, reductions have been achieved through attrition in two directorates. In the Science and Engineering Education Directorate, from September 30, 1981, to December 31, 1981, 15 positions have been eliminated through attrition--bringing onboard strength to 63. A planned September 30, 1982, level of 10 positions could require a reduction in force of 53 positions. In the Scientific, Technological, and International Affairs Directorate, from March 8, 1981, to December 31, 1981, 13 positions were eliminated through voluntary termination and retirement. In order to reach the planned September 30, 1982, level of 171, six positions would have to be eliminated.

As of January 1, 1982, the budget cuts have affected the grant awards of the three directorates. The Scientific, Technological, and International Affairs Directorate was unable to fund approximately 220 continuing grants and planned commitments totaling about $11 million. Other planned commitments have been scaled back. No continuing awards were terminated in the Biological, Behavioral, and Social Sciences Directorate due to lack of funds. However, continuing awards were reduced by about $1.4 million (19 percent of the total amount approved) by the Division of Social and Economic Science and by about $100,000 (2 percent of the total amount approved) in the behavioral sciences. The Science and Engineering Education Directorate did not have to terminate any ongoing grants or fellowships but it estimates that 2,200 new grants that it would have made will not be awarded through fiscal year 1982 due to lack of funds. These figures were provided to us by NSF officials. Because of the short timeframe for completion of our work, we were not able to verify the accuracy of the data.

In each directorate, we have obtained opinions from NSF staff on possible effects of funding cuts. The possible effects were not prioritized and are based on budget figures, which at an aggregate level are substantially lower than the level that was actually passed. Some or all of these effects will change with the higher level of funding.

We would suggest that the information contained in this report would be used best as a basis for asking further questions and should be viewed in light of the effect of the higher amount which has just been appropriated.

As arranged with your office, we did not obtain agency comments on this information in order to meet your requested timeframe. Unless you publicly announce the contents earlier, no further distribution of this report will be made until 30 days after the report date. At that time, we will make copies available to others upon request.

Sincerely yours,

Morton A. Myers

Morton A. Myers
Director

DON FUQUA, FLA., CHAIRMAN
[illegible]
HAMILTON FISH, JR., N.Y.
[illegible]
WILLIAM CARNEY, N.Y.
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RAYMOND J. MC GRATH, N.Y.
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COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
SUITE 2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, D.C. 20515
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November 12, 1981

Honorable Charles A. Bowsher
Comptroller General of the
United States
Washington, D. C.

Dear Mr. Bowsher:

The Subcommittee on Science, Research and Technology is concerned with the effect of recent cuts in certain areas of the National Science Foundation budget. Specifically, we need information on the impact of cuts as they apply to three NSF Directorates: Biological, Behavioral, and Social Sciences; Scientific, Technological, and International Affairs; and Science and Engineering Education.

Budget hearings on NSF's fiscal year 1983 budget are scheduled for the first part of February. For this reason, we need your response by mid-January. We recognize that the short time-frame involved will preclude an extensive or indepth analysis leading to judgments as to the extent of effects in areas that cannot be easily quantified. However, information in areas such as personnel changes, continuity of ongoing research, and program changes that can be quantified, and opinion of NSF staff obtained through interviews, would be of assistance to us.

We look forward to your response and thank you for your continued assistance.

Sincerely,

Doug Walgren

DOUG WALGREN
Chairman
Science, Research and
Technology Subcommittee

DF/Hmr

Table 1

Comparison of Funding for the National Science Foundation
Fiscal Years 1980, 1981, and 1982 $(Millions)

Directorate	Actual 1/ FY1980	Est. Actual FY1981	% Change 2/ FY80-FY81	Est. 3/ FY1982	% Change 2/ FY81-FY82	% Change 2/ FY80-FY82
Science and Engineering Education	$ 77.2	$ 70.7	- 8.4	$ 8.7	- 87.7	- 88.7
Biological, Behavioral, and Social Sciences	185.7	184.4	- .7	157.4	- 14.6	- 15.2
Scientific, Technological, and International Affairs	36.6	37.0	+ .8	28.2	- 23.6	- 23.0
Mathematical and Physical Sciences	227.0	256.2	+ 12.9	249.4	- 2.7	+ 9.9
Engineering	76.6	85.4	+ 11.5	88.2	+ 3.3	+ 15.1
Astronomical, Atmospheric, Earth, and Ocean Sciences 4/	293.4	325.3	+ 11.0	307.3	- 5.5	+ 4.8
Cross Directorate Programs	15.6	16.1	+ 3.3	5.0	- 68.9	- 67.9
Program Development and Management	58.2	59.7	+ 2.5	62.2	+ 4.2	+ 6.8
Special Foreign Currency	4.8	5.6	+ 15.2	3.1	- 44.6	- 36.2
Total-NSF (Planned)	$975.1	$1040.4	+ 6.7	$909.5	- 12.6	- 6.7
Comparison in Constant FY1980 $(Millions) 5/						
Science and Engineering Education	$ 77.2	$ 64.6	- 16.4	$ 7.3	- 89.7	- 90.6
Biological, Behavioral, and Social Sciences	185.7	168.5	- 9.3	131.6	- 21.9	- 29.1
Scientific, Technological, and International Affairs	36.6	33.7	- 7.9	23.6	- 30.0	- 35.6
Mathematical and Physical Sciences	227.0	234.1	+ 3.1	208.6	- 10.9	- 8.1
Engineering	76.6	78.0	+ 1.8	73.8	- 5.4	- 3.7
Astronomical, Atmospheric, Earth, and Ocean Sciences 4/	293.4	297.2	+ 1.3	257.0	- 13.5	- 12.4
Cross Directorate Programs	15.6	14.7	- 5.6	4.2	- 71.6	- 73.2
Program Development and Management	58.2	54.5	- 6.3	52.0	- 4.6	- 10.7
Special Foreign Currency	4.8	5.1	+ 5.3	2.6	- 49.3	- 46.6
Total-NSF (Planned)	$975.1	$950.4	- 2.5	$760.7	- 20.0	- 22.0

1/ The FY1980 amounts have been amended to reflect program changes that occured during FY1981.

2/ The percent change was computed using dollar amounts before rounding.

3/ The budget figures shown for FY1982 are based on a projection of the budgeted rate of obligation for the first quarter of FY1982. They are used to show what the impact would be if that rate of obligation were experienced throughout the remainder of the fiscal year.

4/ The Astronomical, Atmospheric, Earth, and Ocean Sciences Directorate includes funding for Ocean Drilling and the Antarctic program.

5/ The GNP implicit price deflator for FY1980 is 176.72, for FY1981 is 193.44, and FY1982 is 211.3.

SCIENCE AND ENGINEERING EDUCATION DIRECTORATE

The Science and Engineering Education Directorate (SEE) has had broad responsibility for initiating and supporting programs to strengthen science and engineering education. One of its responsibilities has been to help all citizens increase their basic understanding of science and its contributions to the quality of life. Another responsibility has been to assure a stable flow of the most talented students into careers in science and engineering, with particular reference to increasing the participation of minorities and women. Special emphasis has been placed on four areas which include early adolescence, groups underrepresented in science (women, minorities, and the physically handicapped), out-of-classroom learning, and undergraduate faculty development. The Directorate has been divided into four operating units: Scientific Personnel Improvement, Science Education Resources Improvement, Science Education Development and Research, and Science Education Communication.

Impact Highlights

The Directorate has been almost eliminated for fiscal year 1982 (see table 2). During fiscal years 1980 and 1981, the Directorate had been funded at levels of $77.2 and $70.7 million respectively. The only program element remaining in fiscal year 1982 is the graduate fellowship program which is designed to assure that talented graduate students in the sciences obtain the education necessary to become top quality scientific researchers. Unless fiscal year 1982 funding is increased from $8.7 million, NSF will be unable to renew some ongoing fellowships, and will have to forego awarding new grants during fiscal year 1982.

Data on Impact

The following information was provided to us by NSF officials. Because of the short timeframe for completion of our work, we were not able to verify the accuracy of the data.

--The projected end-of-year onboard strength for the Directorate for September 30, 1982, is 10 full-time permanent positions. On September 30, 1981, the staff level was 78 positions. As of December 31, 1981, the staff level had been reduced to 63 positions through the attrition of 15 positions. NSF officials informed us that the Directorate is overstaffed and they may have to RIF as many as 53 positions within the next few months.

--Overall attrition for the Directorate since March 1981 has been 43 full time permanent positions from an end-of-year onboard strength of 106 positions as of September 30, 1980.

Table 2

Comparison of Funding for the Science and Engineering Education Directorate
Fiscal Years 1980, 1981, and 1982 $(Millions)

Program Description	Actual[1/] FY1980	Est. Actual FY1981	% Change[2/] FY80-FY81	Est.[3/] FY1982	% Change[2/] FY81-FY82	% Change[2/] FY80-FY82
Faculty Improvement	$ 11.8	$ 10.2	- 13.7	0.0	-100.0	-100.0
Fellowships and Traineeships	14.0	14.0	+ 0.5	8.7	- 38.0	- 37.7
Student Oriented Programs	5.1	5.7	+ 11.1	0.0	-100.0	-100.0
Minorities, Women, and Handicapped	2.2	3.5	+ 56.2	0.0	-100.0	-100.0
Total-Scientific Personnel Improvement	33.1	33.4	+ 0.8	8.7	- 73.9	- 73.7
Comprehensive Assistance to Undergraduate Sci. Ed.	13.3	8.9	- 33.0	0.0	-100.0	-100.0
Undergraduate Instructional Improvement	5.7	6.1	+ 8.2	0.0	-100.0	-100.0
Resource Centers for Science and Engineering	2.7	2.8	+ 1.0	0.0	-100.0	-100.0
Minority Institution Science Improvement	0.1	0.0	-100.0	0.0	-100.0	-100.0
Total-Science Education Resources Improvement	21.8	17.8	- 18.3	0.0	-100.0	-100.0
Development in Science Education	8.1	6.2	- 24.0	0.0	-100.0	-100.0
Research in Science Education	5.7	4.7	- 16.8	0.0	-100.0	-100.0
Total-Science Education Development and Research	13.8	10.9	- 21.1	0.0	-100.0	-100.0
Public Understanding of Science	3.9	4.3	+ 9.9	0.0	-100.0	-100.0
Information Dissemination for Science Education	1.3	1.2	- 3.7	0.0	-100.0	-100.0
Ethics and Values in Science and Technology 4/	1.3	2.0	+ 55.2	0.0	-100.0	-100.0
Science for Citizens 4/	2.0	1.1	- 46.3	0.0	-100.0	-100.0
Total-Science Education Communication	8.5	8.6	+ 1.2	0.0	-100.0	-100.0
Total-Science and Engineering Education	$ 77.2	$ 70.7	- 8.4	$ 8.7	- 87.7	- 88.7
Comparison in Constant FY1980 $(Millions)[5/]						
Fellowships and Traineeships	$ 14.0	$ 12.8	- 8.2	$ 7.3	- 43.2	- 47.9
All Other Programs	63.2	51.8	- 18.1	0.0	-100.0	-100.0
Total-Science and Engineering Education	$ 77.2	$ 64.6	- 16.4	$ 7.3	- 89.7	- 90.6

1/ See footnote 1/ for Table 1.

2/ See footnote 2/ for Table 1.

3/ See footnote 3/ for Table 1.

4/ The Ethics and Values in Science and Technology and Science for Citizens programs are included here for comparative purposes. During 1981 these programs were transferred to the Scientific, Technological, and International Affairs Directorate and subsequently scheduled for elimination. However, they were funded by the Science and Engineering Education Appropriation.

5/ See footnote 5/ for Table 1.

--Ordinarily, the Science and Engineering Education Directorate would award about 450 new fellowships each year and provide support for another 950 continuing fellows. In addition the Directorate would award about 1,600 grants, making the total number of awards each year approximately 3,000. At the $8.7 million level, no grants could be awarded and only about 800 fellowships could be supported in fiscal year 1982. Thus there would be a total of about 1,600 grants and 600 fellowships that would not be funded during the fiscal year.

--If the $22 million reported out of conference were appropriated for fiscal year 1982, it would allow the graduate fellowships program to continue uninterrupted. NSF officials informed us that it would also permit them to meet most of $5.1 million in prior year commitments involving 60 ongoing projects in areas such as Undergraduate Engineering Education Development Programs and Basic Research Grants in Science and Engineering Education. The remaining 1540 grants would still not be funded during the fiscal year.

--NSF had planned to increase the education allowance for fellowships from $3,400 per year to $4,000 per year. They also had planned to increase the stipend for fellowships from $4,800 to $6,900 for fiscal year 1982. However, because of the current level of budget authority, the education allowance will be limited to $3,400 and the stipend increased to $6,400.

NSF Staff Opinions

This information represents opinions of NSF staff including their views on the impact of NSF's funding cuts on the communities and objectives they serve. The information has not been verified and does not necessarily represent an agency position on the subjects addressed.

--NSF officials believe that the total elimination of science and engineering education programs will harm the future ability of educators to provide students at all levels with the advanced knowledge and training they will need in order to function fully as members of a rapidly advancing technological society.

--NSF has not been providing sustaining support for the ongoing operations of educational institutions. NSF's role has been one of providing grants which have served as vehicles for changes and improvements in science and engineering education. This "seed" money operates as a catalyst that attracts additional funding from both private and other public sources which prefer to contribute to NSF sponsored activities because of their guaranteed quality. Some examples are the PBS television series such as "NOVA" and the "3-2-1 Contact" programs for children.

--NSF's proportion of total national expenditures for science and engineering education has been very small, but as a proportion of expenditures for changing and improving education, its impact has been significant. For example, the "BASIC" computer language which provides many students with their first exposure to computer science was developed under an NSF science education grant.

--One of the benefits associated with NSF's mode of support of science and engineering education that has been expressed by educators has been the quality control provided by NSF's peer review system. This system is rigorous and assures that only the most meritorious proposals are funded.

--Another spin-off from the high quality of NSF-sponsored projects is the translation of materials and programs into other languages for use by other countries. For example, the "3-2-1 Contact" program has been translated into Spanish. The Japanese are making widespread use of instructional material in their math and science curricula which were developed under NSF-sponsored educational research and development grants.

--The impact of eliminating the NSF science and engineering education programs is to effectively remove NSF from its role as the national focal point for science and engineering education issues and information of national interest. This will shift the emphasis of the Directorate from a multi-level program to that of a program limited to graduate fellowships.

--The greatest negative impact will be on small 2- and 4-year institutions with women's and minority institutions being hit particularly hard.

--The other major national organization similar to NSF is the National Institute for Education (NIE). However, NIE is locked into its own ongoing commitments and the prospects are practically nonexistent that it can take up the slack resulting from NSF's loss of support for education. The most significant national issue NIE is working on today is the school financing problem associated with declining enrollments and the overstock of school facilities. NIE is also heavily involved with the Education Resources Information Centers and the regional education laboratories and centers.

--Mission-oriented Federal agencies, for the most part, have their own budget reductions to contend with and cannot nor would they be predisposed to assume a comprehensive national role in science and engineering education. Only in those instances where other agencies--the Department of Defense (DOD), for example--or certain industries have a particular stake in assuring an adequate supply of skilled employees, would there be a response to education needs. DOD, through a program initiated by the Defense Communication Agency, has recently implemented a pilot program in the Los Angeles school system where ROTC students are encouraged to pursue engineering studies. DOD and industry have also sponsored fellowships as a means of supporting science and engineering education. DOD (Navy, Army, and Air Force) has plans for fellowships in selected areas for fiscal year 1983.

--Other sources of support for science and engineering education are not likely, because for most organizations (both public and private), science and engineering education are considered to be on the fringe of their primary missions. Education is, by its very nature, a long term investment in people. The benefits associated with any improvements in curriculum or materials and breakthroughs in the state-of-the-art usually are not realized for several years. Similarly, terminating NSF education programs will have the most impact in future years, perhaps 5 to 10 years hence.

--Some training for graduate students will continue to be available through NSF's traditional research grants but the science and engineering education programs targeted for women and minorities will be eliminated.

--NSF will no longer be able to facilitate an interface between science organizations or industry and the science and engineering education teachers and educators.

--Another area in which NSF could provide much needed assistance to the Nation's education needs is in emerging opportunities created by the advance of knowledge and technology. For example, the new biology (or biotechnology) is creating whole new fields and perhaps even whole new industries. Similarly, the development of low-cost information technology, especially the computer, calls for major shifts in the Nation's approach to science and engineering education. Because of the elimination of NSF's Science and Engineering Education programs, NSF can no longer provide opportunities for researchers and industry to transfer their knowledge and technology to the classroom where tomorrow's scientists and engineers are being trained.

--Our civilization is technologically oriented, so the science and engineering education program at NSF has become a national issue because of its possible impact on the Nation's competitiveness in the international market place.

--The United States is facing future economic problems and these will only increase if we do not increase our productivity. The demand for qualified workers who can cope with increasingly complex technology will continue to grow; given adequate funding, NSF can make a significant contribution to resolving that need.

--The dissolution of the Science and Engineering Education staff would be particularly detrimental because of the loss of talent which had taken NSF several years to accumulate. Once these people are gone it would be very difficult to form another group that had accumulated an equivalent level of expertise and experience. NSF should continue to act as a catalyst to link the high schools and colleges with researchers and engineers in the field.

BIOLOGICAL, BEHAVIORAL, AND SOCIAL SCIENCES DIRECTORATE

The Biological, Behavioral, and Social Sciences Directorate (BBS) directs its activities to expanding knowledge of life and its processes through an understanding of biological and social phenomena. Research supported by the Directorate ranges from the study of the fundamental molecules of living organisms to studies of the complex interactions of people and societal organizations. The Directorate is divided into five divisions which support research in the areas of Physiological, Cellular and Molecular Biology; Environmental Biology; Behavioral and Neural Sciences; Social and Economic Sciences; and Information Science and Technology.

Impact Highlights

The most significant budget reductions have been in the area of social and economic sciences which has been reduced by about 67 percent from its fiscal year 1980 level. The Behavioral and Neural Sciences Division has been reduced by over 26 percent from its fiscal year 1980 level. Within the Division, the largest reductions were in the cognitive sciences--reduced by 65 percent from the fiscal year 1980 level, and anthropological science--reduced by 23.8 percent. All other divisions have been reduced by less than 10 percent from fiscal year 1980 levels (see table 3).

Data on Impact

The following information was provided to us by NSF officials. Because of the short timeframe for completion of our work we were not able to verify the accuracy of the data.

--The projected end-of-year onboard strength for the Directorate, for September 30, 1982, is 144 full-time permanent positions. As of December 31, 1981, there were 139 full-time permanent employees.

--No continuing awards were terminated due to lack of funds. Attempts to accommodate budget reductions have included the following:

-Reducing the amount of previously approved incremental awards to continuing grants. Between October 1, 1980, and December 31, 1981, continuing awards were reduced by about $1.4 million (19 percent of the total amount approved) by the Division of Social and Economic Sciences and by about $100,000 (2 percent of the total amount approved) in the behavioral sciences. These reductions were selectively negotiated with grantee organizations to ensure that the cuts would not jeopardize the successful conduct of the research. NSF staff report that since NSF attempts to honor the amount

Table 3

Comparison of Funding for the Biological, Behavioral, and Social Sciences Directorate
Fiscal Years 1980, 1981, and 1982 $(Millions)

Program Description	Actual 1/ FY1980	Est. Actual FY1981	% Change 2/ FY80-FY81	Est. 3/ FY1982	% Change 2/ FY81-FY82	% Change 2/ FY80-FY82
Cellular and Physiological Biosciences	$ 27.8	$ 29.8	+ 7.4	$ 28.9	- 3.2	+ 3.9
Molecular and Genetic Biosciences	40.8	43.8	+ 7.3	42.0	- 4.0	+ 3.0
Biological Instrumentation	3.5	4.0	+ 13.4	4.1	+ 2.5	+ 16.2
Total-Physiology, Cellular, and Molecular Biology	72.1	77.6	+ 7.6	75.0	- 3.4	+ 4.0
Ecological Science	19.8	21.0	+ 6.2	20.4	- 2.9	+ 3.2
Systematic and Population Biology	19.9	20.0	+ .3	19.2	- 4.0	- 3.7
Total-Environmental Biology	39.7	41.0	+ 3.2	39.6	- 3.4	- .3
Neuroscience	20.2	20.8	+ 3.0	18.7	- 10.1	- 7.4
Cognitive Science	10.0	8.3	- 17.0	3.5	- 57.8	- 65.0
Anthropological Science	6.6	6.0	- 8.5	5.0	- 16.7	- 23.8
Total-Behavioral and Neural Sciences	36.8	35.1	- 4.7	27.2	- 22.5	- 26.1
Economics and Geography	13.8	10.4	- 24.5	4.1	- 60.1	- 69.9
Social Measurement and Analysis	10.4	8.0	- 23.4	3.8	- 52.5	- 63.6
Political and Policy Science	7.2	6.4	- 10.8	2.5	- 61.7	- 65.8
Total-Social and Economic Science	31.4	24.8	- 21.0	10.4	- 58.1	- 66.7
Information Science	3.8	4.2	+ 11.8	4.0	- 4.8	+ 6.5
Information Technology	.2	.2	- 13.8	.4	+100.0	+ 72.4
Information Impact	1.7	1.5	- 9.1	.8	- 46.7	- 51.5
Total-Information Science and Technology	5.7	5.9	+ 4.6	5.2	- 11.9	- 7.8
Total-Biological, Behavioral, and Social Sciences	$185.7	$184.4	- .7	$157.4	- 14.6	- 15.2

Comparison in Constant FY1980 $(Millions) 4/

Program Description	Actual 1/ FY1980	Est. Actual FY1981	% Change 2/ FY80-FY81	Est. 3/ FY1982	% Change 2/ FY81-FY82	% Change 2/ FY80-FY82
Cellular and Physiological Biosciences	$ 27.8	$ 27.2	- 1.9	$ 24.1	- 11.4	- 13.1
Molecular and Genetic Biosciences	40.8	40.0	- 2.0	35.2	- 12.1	- 13.8
Biological Instrumentation	3.5	3.7	+ 3.6	3.4	- 6.2	- 2.8
Total-Physiology, Cellular, and Molecular Biology	72.1	70.9	- 1.7	62.7	- 11.5	- 13.0
Ecological Science	19.8	19.2	- 2.9	17.1	- 11.1	- 13.7
Systematic and Population Biology	19.9	18.3	- 8.4	16.0	- 12.1	- 19.5
Total-Environmental Biology	39.7	37.5	- 5.7	33.1	- 11.6	- 16.6
Neuroscience	20.2	19.0	- 5.9	15.7	- 17.7	- 22.6
Cognitive Science	10.0	7.6	- 24.2	2.9	- 61.4	- 70.7
Anthropological Science	6.6	5.5	- 16.4	4.2	- 23.7	- 36.2
Total-Behavioral and Neural Sciences	36.8	32.1	- 12.9	22.8	- 29.1	- 38.2
Economics and Geography	13.8	9.5	- 31.0	3.5	- 63.5	- 74.8
Social Measurement and Analysis	10.4	7.3	- 30.0	3.2	- 56.5	- 69.6
Political and Policy Science	7.2	5.8	- 18.5	2.0	- 65.0	- 71.4
Total-Social and Economic Science	31.4	22.6	- 27.8	8.7	- 61.6	- 72.3
Information Science	3.8	3.8	+ 2.1	3.3	- 12.8	- 11.0
Information Technology	.2	.2	- 21.1	.3	+ 83.1	+ 44.4
Information Impact	1.7	1.4	- 17.0	.7	- 51.2	- 59.5
Total-Information Science and Technology	5.7	5.4	- 4.4	4.3	- 19.3	- 22.9
Total-Biological, Behavioral, and Social Sciences	$185.7	$168.5	- 9.3	$131.6	- 21.9	- 29.1

1/ See footnote 1/ for Table 1.
2/ See footnote 2/ for Table 1.
3/ See footnote 3/ for Table 1.
4/ See footnote 5/ for Table 1.

of previously approved awards and because budgets for continuing awards are carefully reviewed at the time the first increment of such an award is made, there is little room for further budget reductions.

-Sharply limiting the number of continuing awards, which entail funding from future year appropriations (only one such award has been made by the Division of Social and Economic Science in the first quarter of fiscal year 1982).

-Reducing the amount of funds awarded for new starts.

-Attempting to arrange for joint funding with other units of NSF or with other Federal agencies for projects of mutual interest.

--The cutbacks have already affected the community; fewer proposals are being submitted in social, economic, cognitive, and anthropological sciences. For example, in the social and developmental psychology program, there is usually an average of 50-60 proposals per panel (peer review of proposals by an assembled panel of experts). The last panel was canceled because only nine proposals were received. In this program, there are ordinarily three panels per year. Some program officials have had to send notices to the scientists in the field to let them know that NSF is still awarding some grants.

NSF Staff Opinions

This information represents opinions of NSF staff including their views on the impact of NSF's funding cuts on the communities and objectives they serve. The information has not been verified and does not necessarily represent an agency position on the subjects addressed.

--In the United States, social and behavioral basic research is done primarily in the universities, heavily funded by the Federal Government. In the social, economic, cognitive, and anthropological sciences, a significant portion of these funds has been withdrawn. For at least the next 5 years, the funds will not be made up from other sources. Given what the Federal Government now has to spend on basic research in these areas, they will just not move ahead.

--If there is an extended period of reduced funding of basic research in the social, economic, cognitive, and anthropological sciences, researchers presently doing basic research in these areas will not continue working in basic research.

--Fewer scientists will be entering the fields of social economic, cognitive, and anthropological sciences since the opportunities will be so diminished. Many graduate students receive training on grants awarded to their professors. With fewer grants there will be substantially less opportunity for this to occur.

--With fewer scientists, less basic research will be accomplished. The social, economic, cognitive, and anthropological sciences fields will suffer in the long run as there will be a reduction in the growth of basic research upon which to build.

--Less empirical research will be accomplished in the social, economic, cognitive, and anthropological sciences with more reliance on speculative analysis and analysis based on information from secondary sources. NSF provides funds for the collection of data for the analysis of U.S. societal trends, e.g., National Election Studies and the Panel Study of Family Income Dynamics. Funds for data bases such as these are being severely reduced. There is the possibility of some data bases being discontinued next year if more funds are not received. Various new data collection activities will not be started. Although the maintenance of these data bases is a top priority, not all of them can be continued if the funding levels remain at what they are now.

--In some cases, information that is not obtained now will be lost forever. For example, in anthropology, if research is not done in certain areas soon, because of civilization encroaching on sites or indigenous cultures dying out, it will never be done. While this type of work should certainly be given preference, it cannot all be done within the budget constraints. One of the projects that will not be funded by the NSF anthropology program due to the budget reductions is a project to obtain deep cores from one or more deep African lakes for the purposes of reconstructing climate and other aspects of early man's environment in these regions. Besides giving scientists information about Africa's paleoclimate and clues on petroleum formation, this project is highly significant to researchers studying the ancient African environment and ancient animal and plant life. In the area where the deep cores were to be obtained, there is now evidence of major deposits of oil. Removing the oil could damage the site.

--NSF is one of the only Federal agencies whose support for basic research is not in some way mission oriented--that is, oriented towards accomplishing a specific practical goal for the agency (a cure for cancer, a disease resistant crop plant, etc.). Without substantial support from NSF, the long range view will be short-changed.

--Other Federal agencies are also receiving substantial reductions in the same areas as NSF, making the impact that much more severe. While DOD is receiving more funds, DOD's research is mission oriented as described above.

--There appears to be no increased support for basic research coming from the private foundations to compensate for the reductions in NSF funds. Representatives from some of the major foundations (e.g., Ford, Rockefeller, Sloan, Carnegie) all made it very clear, in a meeting with NSF officials, that they know of no foundation that would modify its plans to adjust to the reduction in NSF funds.

--Within these reduced budgets, NSF programs must also support applied research for the first time--further diminishing available funds. Previously, applied research was supported as a separate activity.

--The ability to describe, analyze, and model complex ecosystems which include human communities depends on integrating scientists from different disciplines and on gathering environmental data over time. Reduced funding will threaten potential breakthroughs in modeling ecosystems, which include human as well as nonhuman components.

--The particular expertise of anthropologists in generating information about the rural and urban societies of less developed nations and in providing new ways of seeking solutions to underdevelopment has been widely recognized by development planners in national and international development agencies. Anthropologists' participation in planning and delivering development assistance is now widely recognized as one means to provide more effective development programs. A reduction of funds will seriously jeopardize ongoing scientific analysis in demography, farm systems research, rural-urban migration, and other research areas that have contributed to improved results from our investment in international assistance programs.

--Since the linguistics program (contained in the cognitive science area of the Behavioral and Neural Sciences Division) operates entirely on the basis of unsolicited proposals, it is impossible to predict exactly what research opportunities will be lost as a consequence of the availability of virtually no funds for proposals during fiscal year 1982. An example of a project which ordinarily would be expected to have renewed support in fiscal year 1982, but will be terminated is a project on the acquisition of the properties of speech by children learning language. This is a little understood topic which, it is becoming increasingly clear, is fundamental to the language acquisition process.

--The reduced funds available in fiscal year 1982 will have a dramatic effect on the development of research in human cognition. The loss from not funding renewals that otherwise would have been funded is a major loss which ranges from a retardation of the pace of scientific progress at best to total elimination of the insights we would achieve from major areas of research at worst. While research in human cognition will not grind to a halt, the budget cuts will produce the potential for major long-term damage to the field.

--The psychobiology program (contained in neuroscience) is the primary source of Federal support for research on animal behavior. A number of relatively high-cost lines of research will be most seriously affected. Such areas include research on captive primates and other large animals, field research outside the United States, research depending on modern biochemical techniques (such as behavioral endocrinology), and relatively large, longer-term projects for which 3- to 5-year support is essential.

--With respect to social psychology (in the social and developmental psychology program in the cognitive sciences area), it will be impossible to continue funding several lines of research that have recently shown considerable promise. For example, research on social cognition has now advanced to the point at which direct links between the cognitive processes studied and overt social behavior can be established. Reductions in funding will hinder further progress along these lines. Damaging effects also will be felt in the field of social development. Much of the research conducted in this area is longitudinal in nature, i.e., it involves careful study of the same group of subjects over prolonged periods of time in order to observe systematic changes in behavior occurring during this interval. As a result of the large scheduled reductions in budget, such work will generally be brought to a close. The loss of continuity in data collection cannot be replaced even if research funds are restored at some future time.

--Research will be curtailed on how technological innovations, productivity, changing inter-industry linkages, large-scale decisionmaking, public policies, and other factors affect the geographic distribution of economic development and stagnation in different parts of the country.

--Although contingency plans are being made to mitigate the effects of budget reductions on the social science data base, more than two decades of effort toward monitoring social change, providing data sets for research on important empirical phenomena, and generally maintaining the infrastructure of contemporary social and economic science will be greatly impaired. It is no longer easy to envision great strides in social and economic science without large scale data collections and the maintenance of facilities which "clean", store, distribute, and provide the capability for integrating the data collected in preparation for specialized analyses.

--With very limited funds, the work most likely to be fruitful for policymaking over the next 5 years--that is, the careful empirical work--will be cut back, while new conceptual (and less expensive) research will be emphasized.

SCIENTIFIC, TECHNOLOGICAL, AND INTERNATIONAL AFFAIRS DIRECTORATE

The goals of the Scientific, Technological, and International Affairs Directorate (STIA) are to (1) link the producers of research with the users of research, (2) support research analyses and data collections on the interactions between science, technology, and public policy, and (3) facilitate the international exchange of scientific and technical information. To achieve these goals, the Directorate supports cooperative research between universities and industry, and between scientists, engineers, and the general public. Its international science programs support joint efforts with advanced and developing countries. The Directorate also supports data collections, research, analyses, and reporting on the science and technology enterprise and its impact on society. The Directorate is divided into five groups: Industrial Science and Technological Innovation, International Cooperative Activities, Policy Research and Analysis, Science Resources Studies, and Intergovernmental and Public Service Science and Technology.

Impact Highlights

Overall, the Directorate has experienced a budget reduction of 23 percent from fiscal year 1980 levels (see table 4). In Industrial Science and Technological Innovation, there has been an increase in support for Small Business Innovation over the fiscal year 1980 budget while other functions have been reduced or eliminated. Reductions have been made in areas of the Directorate where data gathering, analyses, and research of science policy issues are being undertaken. NSF's support for International Cooperative Activities for 1982 will be limited to the International Cooperative Science Program and support for the National Academy of Sciences' membership in the International Institute for Applied Systems Analysis (1982 will be the last year that NSF funds U.S. membership). The other functions of the Division will be funded elsewhere in NSF. Intergovernmental and Public Service Science and Technology has been reduced 91 percent from fiscal year 1980. Support to State and local governments will be sharply curtailed while some programs such as the Appropriate Technology, University Based Innovation Centers, and State Science and Engineering Technologies Programs will be totally eliminated.

Data on Impact

The following information was provided to us by NSF officials. Because of the short timeframe for completion of our work, we were not able to verify the accuracy of the data.

--The projected end-of-year onboard strength for the Directorate, for September 30, 1982, is 171 full-time permanent positions. On December 31, 1981, the staff level was 177 positions. The Directorate may have to RIF as many as six positions by the end of the fiscal year.

Table 4

Comparison of Funding for the Scientific, Technological, and International Affairs Directorate

Fiscal Years 1980, 1981, and 1982 $(Millions)

Program Description	Actual FY1980 1/	Est. Actual FY1981	% Change FY80-FY81 2/	Est. FY1982 3/	% Change FY81-FY82 2/	% Change FY80-FY82 2/
Industry/University Cooperative Projects	$ 5.1	$ 8.1	+ 60.4	$ 5.0	- 38.3	- 1.0
Small Business Innovation	2.0	5.0	+142.0	4.5	- 10.0	+117.8
Industry/University Cooperative Centers	1.3	1.5	+ 19.7	1.0	- 33.3	- 20.2
University Based Innovation Centers	.5	1.2	+127.3	0.0	-100.0	-100.0
Innovation Process Research	1.5	1.1	- 26.9	.5	- 54.5	- 66.8
Total-Industrial Science and Tech. Innovation	10.4	16.9	+ 62.5	11.0	- 34.9	+ 5.8
Scientific Cooperation with Western Europe	1.5	1.1	- 30.2	2.2	+111.5	+ 47.7
Scientific Cooperation with Eastern Europe	3.3	2.1	- 36.6	1.9	- 10.8	- 43.5
Scientific Cooperation with Asia	2.6	2.5	- 3.1	2.9	+ 15.1	+ 11.5
Scientific Cooperation with Africa and Latin Am.	1.7	1.0	- 45.6	1.3	+ 39.8	- 24.0
International Travel Grants	.7	.7	+ .3	0.0	-100.0	-100.0
International Scientific Orgs. and Resources	3.9	2.7	- 30.0	2.0	- 26.2	- 48.3
Total-International Cooperative Activities	13.7	10.1	- 27.0	10.3	+ 2.0	- 25.0
Socioeconomic Effects of Science and Technology	1.3	1.9	+ 53.2	1.7	- 13.2	+ 20.4
Technology Assessment and Risk Analysis	1.3	1.4	+ 10.0	1.2	- 14.3	- 5.7
Environment, Energy, and Resources	.9	1.1	+ 23.0	.8	- 22.7	- 4.9
Total-Policy Research and Analysis	3.5	4.4	+ 24.4	3.7	- 16.9	+ 4.6
Scientific and Technical Personnel	2.0	1.5	- 23.3	1.6	+ 3.3	- 20.8
Funding of Science and Technology	.7	.9	+ 30.5	.7	- 22.2	+ 15.4
Modeling and Special S&T Indicators	.8	.7	- 16.9	.4	- 42.9	- 52.5
Total-Science Resources Studies	3.5	3.1	- 10.1	2.7	- 12.9	- 21.7
Intergovernmental Programs	4.5	2.0	- 55.7	.5	- 75.0	- 88.9
Public Service Science and Technology	1.0	.5	- 50.6	0.0	-100.0	-100.0
Total-Intergovernmental and Pub. Svc. S&T	5.5	2.5	- 54.8	.5	- 80.0	- 91.0
Total-Scientific, Technological, and Int. Affairs	$ 36.6	$ 37.0	+ .8	$ 28.2	- 23.6	- 23.0

Comparison in Constant FY1980 $(Millions) 4/

Program Description	Actual FY1980 1/	Est. Actual FY1981	% Change FY80-FY81 2/	Est. FY1982 3/	% Change FY81-FY82 2/	% Change FY80-FY82 2/
Industry/University Cooperative Projects	$ 5.1	$ 7.4	+ 46.5	$ 4.2	- 43.5	- 17.2
Small Business Innovation	2.0	4.5	+121.1	3.8	- 17.6	+ 82.2
Industry/University Cooperative Centers	1.3	1.4	+ 9.3	.8	- 39.0	- 33.3
University Based Innovation Centers	.5	1.1	+107.6	0.0	-100.0	-100.0
Innovation Process Research	1.5	1.0	- 33.2	.4	- 58.4	- 72.2
Total-Industrial Science and Tech. Innovation	10.4	15.4	+ 48.4	9.2	- 40.4	- 11.5
Scientific Cooperation with Western Europe	1.5	1.0	- 36.2	1.8	+ 93.7	+ 23.5
Scientific Cooperation with Eastern Europe	3.3	2.0	- 42.1	1.6	- 18.3	- 52.7
Scientific Cooperation with Asia	2.6	2.3	- 11.5	2.4	+ 5.3	- 6.8
Scientific Cooperation with Africa and Latin Am.	1.7	.8	- 50.3	1.1	+ 27.9	- 36.4
International Travel Grants	.7	.6	- 8.5	0.0	-100.0	-100.0
International Scientific Orgs. and Resources	3.9	2.5	- 36.0	1.7	- 32.4	- 56.8
Total-International Cooperative Activities	13.7	9.2	- 33.3	8.6	- 5.9	- 37.2
Socioeconomic Effects of Science and Technology	1.3	1.7	+ 26.6	1.4	- 20.5	+ .7
Technology Assessment and Risk Analysis	1.3	1.3	+ .5	1.0	- 21.5	- 21.1
Environment, Energy, and Resources	.9	1.0	+ 12.4	.7	- 29.3	- 20.5
Total-Policy Research and Analysis	3.5	4.0	+ 13.6	3.1	- 23.0	- 12.5
Scientific and Technical Personnel	2.0	1.4	- 30.0	1.3	- 5.4	- 33.7
Funding of Science and Technology	.7	.8	+ 26.6	.6	- 23.8	- 3.5
Modeling and Special S&T Indicators	.8	.6	- 24.1	.4	- 47.6	- 60.2
Total-Science Resources Studies	3.5	2.8	- 17.9	2.3	- 20.3	- 34.5
Intergovernmental Programs	4.5	1.8	- 59.5	.4	- 77.1	- 90.7
Public Service Science and Technology	1.0	.5	- 54.9	0.0	-100.0	-100.0
Total-Intergovernmental and Pub. Svc. S&T	5.5	2.3	- 58.7	.4	- 81.7	- 92.4
Total-Scientific, Technological, and Int. Affairs	$ 36.6	$ 33.7	- 7.9	$ 23.6	- 30.0	- 35.6

1/ See footnote 1/ for Table 1.
2/ See footnote 2/ for Table 1.
3/ See footnote 3/ for Table 1.
4/ See footnote 5/ for Table 1.

- --During March 1981 a reorganization caused the transfer of several personnel both into and out of the Directorate. The staff level was 190 on March 8, 1981. Since March the staff level has decreased to the current level of 177. This was accomplished through 13 voluntary terminations and retirements.

- --As of January 1, 1982, approximately 220 continuing grants and planned commitments at a level of about $11 million have not been met because of lack of funds. Other planned commitments have been scaled back.

NSF Staff Opinions

This information represents opinions of NSF staff including their views on the impact of NSF's funding cuts on the communities and objectives they serve. The information has not been verified and does not necessarily represent an agency position on the subjects addressed.

- —The cuts are so severe that entire functions have been totally deleted. The philosophy behind this has been to try to maintain essential basic activities that are unique, rather than spreading the money too thinly on all the functions previously supported.

- --The Directorate is now at the minimum level at which the activities now being funded can remain viable.

- --The budget reductions raise the question of whether NSF is reduced to a concern for only academic disciplinary research support. It is a serious policy question that should be decided before cuts such as these are made--not after.

Industrial Science and Technological Innovation

- --The principal objective of the Innovation Processes Research Section is to improve understanding of the processes by which technological innovation occurs and those processes are affected by Federal objectives and actions. A new program announcement was to go into effect during fiscal year 1982. Among the topics addressed in this announcement were research on small business innovation, university-industry interaction, and the dissemination and implementation of manufacturing technology. The proposed budget cut for fiscal year 1982 would preclude new research from being funded as remaining funds will be used mostly to honor past commitments.

- --University Based Innovation Centers have been eliminated. These centers developed and trained entrepreneurs and inventors in bringing ideas to market and starting new businesses. Two other programs in the section, the

Industry/University Cooperative Projects and the Industry/University Cooperative Centers have received budget reductions. The Industry/University Cooperative Projects sponsor cooperative projects to strengthen research ties between universities and industry researchers and thereby improve the effectiveness of the Nation's science and technology enterprise. One of the effects of the cuts will be to discourage future planned research cooperation sponsored by NSF between industry and universities. The objective of the Industry/University Cooperative Centers Program is to create research centers where industrial and university scientists and engineers may carry out work jointly on technologies that have potential applications across a number of sectors of the economy. Over time, NSF support for individual centers will decrease and industry support will increase. After 5 years, NSF support ends. The fiscal year 1982 request will allow the phased support of five operating centers, no starts for centers from existing planning grants, and no new planning grants.

--The following is an example of the type of work that the Industry/University Cooperative Centers Program funds. One project is designed to develop specialized solid-state chips to examine outputs for a number of different types of signals under the same kind of circumstances. Sensory devices will examine changes as they occur and readjust other mechanisms to compensate for them. For example, these chips could be used to analyze all the various functions an airplane pilot must take into account and to adjust them as necessary simultaneously instead of analyzing each function separately. This would reduce the time necessary to accomplish the tasks and be more effective and efficient than analyzing each situation separately. The reduction in time necessary to accomplish these actions could quite possibly be life-saving in tight time situations.

--Due to the budget reductions in the Industry/University Cooperative Projects and Industry/University Cooperative Centers Programs, there will be less opportunity for scientists in industry and the universities to work together. There will be less chances for industry to learn more about the capabilities and advantages of university research, and less chances for universities to learn about the research needs of industry. This funding is useful in exploring mechanisms for longer term collaborative efforts, most of which are not funded by NSF. With the reductions, there will be less collaboration between industry and universities and less work to determine what types of collaboration mechanisms work in different circumstances. With less cooperation, there will be less advancement of the scientific and technological base. While the work being done does not have immediate commercial application, it may have commercial application within 4 to 5 years.

--In projects funded by the Industry/University Cooperative Projects Program, advances have been made in joining industry and university research in instances when the research might not otherwise be undertaken. The research is often one of the critical steps necessary in order for a certain area of technology to advance. For example, one of these critical steps was to try to design a catalyst to make a hydrogen-oxygen fuel cell technically feasible. An organometallic compound has been discovered and this finding can be expanded upon. The eventual goal is commercial use for hydrogen fuel (made from water and electricity) which could have profound economic importance in the long term. An example of a project that the program will not be able to support at the level of funding proposed for fiscal year 1982 is work on new tools that sputter atoms layer by layer onto a surface to build up semiconductor chip bases. Refinement of sputtering sources is important to these new tools. These chip bases are one of the cornerstones of the next generation of circuits. It would improve the quality and reduce the cost of these circuits. If the project had been funded, knowledge from the project would have likely impacted the design of commercially available molecular beam epitaxy tools within the next 3 to 5 years.

International Cooperative Activities

--After calendar year 1982, only one of the functions of this Division will be funded by STIA--the International Cooperative Science Program. This program, which funds bilateral research projects under formal agreements and other formal and informal arrangements, has had some budget reductions. Most present commitments will be honored, but almost all the bilateral programs will be reduced below that planned for fiscal year 1982. Funds for U.S. membership and involvement in the International Council of Scientific Unions and its member unions (international linking of professional and scientific associations or persons within a technical discipline or professional area from the various member countries) will be funded from other areas of NSF. American scientists requesting travel funds to attend international conferences must now compete for funds against research proposals in the same discipline throughout all NSF Directorates. Dues for calendar year 1982 must be paid for U.S. membership and involvement in the International Institute for Applied Systems Analysis (IIASA). However, NSF will not provide any further funds for membership. 1/

1/After the budget reduction was made,an incident occurred which raised the possibility that the United States may have withdrawn support for IIASA dues anyway.

--The International Cooperative Science Program, subdivided on table 4 into Scientific Cooperation with Western Europe, Eastern Europe, Asia, and Africa and Latin America has absorbed about as many reductions as it can sustain without abrogating international agreements. Some bilateral agreements in process will have to be deferred. These agreements have provided national benefits. For example, one cooperative research project under the U.S.-Japan Cooperative Science Program pioneered the development and applications of high voltage electron microscopy in materials science. This cooperative program is particularly important for U.S. researchers because it allows direct involvement with pioneering work by the Japanese in the materials fields with high voltage electron microscopy. Also, this agreement gives American scientists access to the well-equipped technical staff and accessory and support facilities of the Japanese. Although the U.S. recently established a National Center for Electron Microscopy, the Japanese facilities are said to be better equipped than U.S. facilities.

--While membership dues in all the unions which make up the International Council of Scientific Unions are now being paid, there is some concern that in the future some of the unions not directly covered under specific NSF programs will not be joined.

--With the cancellation of the International Travel Grants program, there will be no set budget specifically for attendance of American scientists at international conferences as there has been in the past. Funds for attending these conferences will be competing directly with research proposals by discipline and officials feel that the net result will be fewer Americans attending international conferences. Further, since the requests for travel grants will not be competing against each other across disciplines, the most worthwhile travel grants will not necessarily be funded.

Policy Research and Analysis

--The Division of Policy Research and Analysis (PRA) supports external research and analyses on public policy issues that have substantial science and technology content. This work provides a source of knowledge and information for use by Federal decisionmakers in the Executive Office of the President, Federal agencies, the Congress, and by the general public. Although the fiscal year 1982 funding is actually slightly higher than the actual fiscal year 1980 budget, the 1982 figure contains approximately $600,000 for the International Economic Program, which was not included in the fiscal year 1980 figures. Excluding this $600,000, this Division has been reduced by 12.4 percent from the fiscal year 1980 budget figure. As a result of the reductions, a significant portion of the funds in science and technology policy research will be allocated to continuing grants and those submitted in fiscal year 1981; long-term grants in international economic policy will be reduced by about 25 percent; Technology Assessment and Risk Analysis will only be able to support one new technology assessment project; and intramural policy studies for policymakers in the Executive Office of the President will have to be cut back. One example of past work in the Division has been funding projects to estimate and assess the relationships between Federal research and development expenditures in industry and industry research and development funding. A question frequently raised in discussions about Federal research and development funding is whether these funds increase or decrease industry research and development funding. These studies all indicate that Federal spending in this area complements rather than substitutes for private spending. With the budget reductions, other issues of importance to decisionmakers will not be able to be researched as completely; it will take longer to provide answers to policy questions and these answers will not be analyzed as completely. For example, due to lack of funds, there will be less research done on the issue of tax policy and its impact on innovation. There is not much evidence available now to determine whether more money will be invested in research and development if there are faster tax write-offs. Work on this issue could help provide needed answers.

Science Resources Studies

--The Division of Science Resources Studies provides for the development, collection, maintenance, analysis, and interpretation of timely and comprehensive information on the Nation's science and technology resources. It carries out an ongoing program of surveys and studies in science and technology. The Program for the Analysis of Science Resources will probably fund only 3 out of approximately 36 proposals. This reduction will curtail the development of output and impact science and technology indicators and analyses of science and technology resource data by the academic community. Commissioned studies for special topics for Science Indicators--1982 will be sharply cut. The national conference on innovation indicator development will be eliminated. Survey-related activities will be reduced so that there will be less ability to provide information for special requests and studies.

Intergovernmental and Public Service Science and Technology

--The Intergovernmental Programs Section has been drastically reduced. Program objectives are to strengthen the capacities of State and local governments to make more effective use of scientific and technical resources.

The congressionally-mandated State Science, Engineering, and Technology program has been eliminated. This program was intended ultimately to make grants to both the executive and legislative branches of all 50 States, to strengthen their capacities to use scientific, engineering, and technical resources in their policy planning and administrative management. At this point, planning awards have been made to all 50 States and first-year implementation awards to 15 States; the remainder cannot be funded. The Local Government Programs planned to provide support to 13 statewide and regional innovation networks. At this point, five existing regional networks will continue to receive NSF support at a reduced level; the remaining eight will not be supported. The other programs in the section have also been reduced. The Public Service Program Section will be terminated.

--The Division of Intergovernmental and Public Service Science and Technology provided leadership and coordination in establishing links between scientific and technical resources and important user communities (State and local governments, intermediary organizations, and public interest groups). The aid to State and municipal governments in these areas was considered to be important by these governments. However, they probably will not start up new projects by themselves. Regional networks cannot be expanded without the linkage and organization NSF provides. Thus, specific State and local governments will have less opportunity to learn from the experiences of other governments. Terminating the Public Service Science and Technology Program Section will hamper knowledgeable citizen participation in the resolution of public issues involving science and technology.

Mr. Walgren. I would like to turn now to Mr. Shamansky for his opening remarks.

Mr. Shamansky. Thank you, Mr. Chairman.

I have a prepared statement which I would like to submit for the record.

[The prepared statement of Mr. Shamansky follows:]

STATEMENT
REP. BOB SHAMANSKY
NATIONAL SCIENCE FOUNDATION
2/23/82

MR. CHAIRMAN, I WANT TO RAISE THREE AREAS OF CONCERN IN REVIEWING THE NATIONAL SCIENCE FOUNDATION'S FISCAL YEAR 1983 BUDGET REQUEST. I AM SURE THESE AREAS CONCERN OTHER MEMBERS AS WELL.

THE FEBRUARY 19, 1982, ISSUE OF SCIENCE MAGAZINE OBSERVE "...IN DISCUSSING THE STATE OF SCIENCE AND TECHNOLOGY EDUCATION, DECIMATED IN EARLIER REAGAN BUDGETS, SLAUGHTER (NSF DIRECTOR, DR. JOHN SLAUGHTER) AFFIRMED THAT THE FEDERAL GOVERNMENT HAS A 'ROLE OF LEADERSHIP IN SCIENCE EDUCATION'." HOWEVER, MR. CHAIRMAN, IN REVIEWING THE FUNDING LEVEL FOR THE SCIENCE EDUCATION DIRECTORATE, WE SEE JUST $15 MILLION HAS BEEN ALLOCATED. OF ALL THE PROGRAMS WITHIN THIS DIRECTORATE, GRADUATE FELLOWSHIPS WILL BE THE ONLY ONE TO SURVIVE STOCKMAN'S AXE. FURTHER CUTS ARE MADE DESPITE THIS COMMITTEE'S FINDINGS ON THE POSITIVE CONTRIBUTION THAT THE SCIENCE EDUCATION DIRECTORATE MAKES TO OUR SOCIETY.

THE ARTICLE GOES ON TO SAY THAT "...HE (DR. SLAUGHTER) INDICATED THAT THE COMMISSION ON PRE-COLLEGE EDUCATION IN MATHEMATICS, SCIENCE AND TECHNOLOGY ESTABLISHED BY THE NATIONAL SCIENCE BOARD IN JANUARY WILL BE EXPECTED TO PROVIDE A CONVINCING RATIONALE FOR NSF SCIENCE EDUCATION ACTIVITIES IN THE FUTURE." WE KNOW THE HARMFUL EFFECT THAT INADEQUATE FUNDING AND ATTENTION HAS HAD ON THE PRE-COLLEGE LEVEL IN THE PAST AND PRESENT. THIS COMMISSION WILL BE STUDYING THE OBVIOUS.

According to a draft copy of the Commission's Charter, "the Commission will examine the health and potential of secondary school mathematics, science and technology education in the United States and will make recommendations to the Nation through the National Science Board to address the Nation's needs."

There is nothing wrong with studying the problem associated with pre-college science education. What I fail to understand is the rationale for gutting programs that address the obvious problems we now face in science education. Elimination of funding for programs to train science educators, elimination of student oriented programs, elimination of the directorate's program on public understanding of science — all of these programs are linked. They connect our efforts to improve the level of skilled scientists, high-technology entrepreneurs, academicians, students and the general public understanding of science and technology.

Mr. Chairman, I am submitting for the record a copy of Mr. Lynn Elfner's testimony which was given during this Subcommittee's field hearing in Columbus, Ohio. Mr. Elfner is the Executive Officer of the Ohio Academy of Science and during his testimony on local incentives for high-technology firms and innovation, he addressed his remarks to the National Science Foundation budget request and commented on the Pre-College Commission. I quote:

"...A national disgrace has developed in the proposed FY 1983 Budget of the National Science Foundation. Only $15 million is budgeted for science and engineering education or 1.4% of the total

AGENCY BUDGET OF $1.0728 BILLION! AS RECENTLY AS FY 1981 THE NSF BUDGET FOR SCIENCE AND ENGINEERING EDUCATION WAS $70.7 MILLION OR 6.7%. THE NSF REACTION HAS BEEN TO ALLOCATE $700,000 IN FY 1982 TO ESTABLISH AN AD HOC COMMISSION ON PRE-COLLEGE EDUCATION IN MATHEMATICS, SCIENCE AND TECHNOLOGY TO STUDY THE PROBLEM. NOT A SINGLE PENNY OF THIS $700,000 WILL HAVE AN IMMEDIATE IMPACT ON THE IMPROVEMENT OF SCIENCE AND ENGINEERING EDUCATION IN THE UNITED STATES. TWO YEARS AGO THE NSF PUBLISHED EIGHT VOLUMES (OVER 2000 PAGES) OF REPORTS ON THE STATUS OF PRE-COLLEGE SCIENCE, MATHEMATICS AND SOCIAL STUDIES EDUCATION. AS FAR AS I KNOW THE ONLY OUTCOME OF THESE REPORTS WAS TO ESTABLISH YET ANOTHER STUDY COMMISSION. FRANKLY, SCIENCE EDUCATION AT THE NATIONAL LEVEL IS BEING COMMISSIONED TO DEATH. IN KEEPING WITH THE 'NEW FEDERALISM,' I WOULD URGE YOU AND YOUR CONGRESSIONAL COLLEAGUES TO CARVE OUT A FEW MILLION DOLLARS FOR PROGRAMS AVAILABLE ONLY TO STATE AND LOCAL ORGANIZATIONS LIKE COSI AND THE OHIO ACADEMY OF SCIENCE WHERE OUR LOCAL AND STATE CONSTITUENCIES WILL MAKE SURE THAT THE FUNDS GO TO THE PURPOSE OF BENEFITING PEOPLE DIRECTLY AND NOT FOR MORE STUDIES," END QUOTE.

MR. ELFNER PREFACED HIS REMARKS WITH THE FACT THAT "TO HARVEST THE FRUITS OF SCIENCE SOMEONE HAS TO TEND THE ORCHARD." I AGREE AND OBVIOUSLY DR. SLAUGHTER AGREES, ACCORDING TO HIS REMARKS IN *SCIENCE* MAGAZINE. BUT THE BUDGET BEFORE THIS COMMITTEE DOES NOT. IT DOES NOT SUPPORT THE OBVIOUS REQUIREMENTS FOR SCIENCE EDUCATION IN THIS COUNTRY.

ONE ADDITIONAL COMMENT, MR. CHAIRMAN, AND THAT IS ONE THE ADMINISTRATIVE CHANGES TAKING PLACE IN NSF. ACCORDING TO A LETTER TO CHAIRMAN WLAGREN FROM DR. SLAUGHTER, THE NATIONAL SCIENCE FOUNDATION IS MAKING PLANS TO "DISESTABLISH THE DIRECTORATE FOR SCIENCE AND ENGINEERING EDUCATION, AND IN ITS PLACE...ESTABLISHING THE NEW OFFICE OF SCIENTIFIC AND ENGINEERING PERSONNEL AND EDUCATION. THE NEW OFFICE...WILL BE RESPONSIBLE FOR CONTINUING THE FELLOWSHIPS PROGRAM AND OTHER SELECTED PROJECTS IN THE AREA OF SCIENCE AND ENGINEERING EDUCATION."

IN ADDITION, AN ISSUE BRIEF PROVIDED TO ME BY THE SUBCOMMITTEE STAFF STATES THAT, "CUTS HAVE REDUCED PERSONNEL IN THE EDUCATION DIRECTORATE FROM 106 POSITIONS (FY 81) TO 63 POSITIONS IN DECEMBER, 1981, WITH THE EXPECTATION OF A RIF (REDUCTION-IN-FORCE) OF 53 POSITIONS WITHIN THE NEXT MONTH. SHOULD THIS RIF OCCUR THE DIRECTORATE WOULD HAVE 10 POSITIONS REMAINING IN FY 1983."

ADMINISTRATIVE CHANGES SUCH AS THESE WITHIN THE DIRECTORATE WILL NOT IMPROVE OUR EFFORTS REGARDING SCIENCE EDUCATION IN THIS COUNTRY AND WILL NOT ENCOURAGE PRIVATE INVESTMENT IN SCIENCE EDUCATION. THEY WILL ONLY PUT US FURTHER BEHIND AND MAKE OUR JOBS OR OUR SUCCESSORS JOBS EVEN HARDER IN ALLEVIATING THE ERRORS OF OUR WAYS. EDUCATION, ESPECIALLY SCIENTIFIC AND TECHNICAL EDUCATION, IS A CONTINUUM. ONCE BROKEN, AS THIS BUDGET RISKS DOING, IT IS NOT QUICKLY RESTORE. IN THE INTERIM IMPORTANT AMERICAN TECHNOLOGICAL AND SCIENTIFIC STRENGTHS WILL CONTINUE TO DETERIORATE, WITH EVIL EFFECTS ON OUR ECONOMY, NATIONAL DEFENSE, AND SOCIAL WELL-BEING.

MR. CHAIRMAN, I WILL SUPPORT INITIATIVES BY MY COLLEAGUES TO FUND ADEQUATELY THE SCIENCE AND ENGINEERING DIRECTORATE AND TO MAINTAIN CURRENT ADMINISTRATIVE POLICIES UNTIL CONGRESS HAS HAD THE OPPORTUNITY TO ACT ON THE PRESIDENT'S BUDGET REQUEST.

THANK YOU.

-- BOB SHAMANSKY

Mr. **Shamansky**. Dr. Slaughter, I do not want to miss the opportunity at the beginning of the National Science Foundation authorization hearings to quote from the February 19, 1982, issue of Science magazine which observes:

> In discussing the state of science and technology education decimated in earlier Reagan budgets, Dr. Slaughter affirmed that the Federal Government has a role of leadership in science education.

However, Mr. Chairman, in reviewing the funding level for the science education directorate we see just $15 million has been allocated. Of all the programs within this directorate, graduate fellowships will be the only ones to survive Mr. Stockman's axe. Further cuts are made despite this committee's findings of the positive contribution that the science education directorate makes to our society.

I want to add, sir, that the approach of this administration to science and engineering education looks to me to be the American equivalent of the Chinese cultural revolution. It is a mindless attack on something which is a continuum. Science and engineering education is a continuum. You cannot snip it here and pick it up 5, 10, or 15 years later and expect to have the kind of science and engineering establishment that we must have to survive.

When I say that I do not envy you your responsibilities in trying to handle this kind of onslaught, that really does not absolve you, in my estimation, from a very real responsibility for, I will say, being an accomplice for this kind of desecration.

There is no way that we can take testimony week after week here and find that the doctoral candidates in science and engineering in this country are made up about 50 percent of students from overseas and then learn that graduate students will be denied student loans. It is simply contradictory.

This administration had money to continue the tobacco subsidy program. It has money for lots of things, like subsidized water for the dry West and Southwest. The Secretary of Defense last year could find only 1-percent waste, fraud, and abuse in a military budget of in excess of $200 billion. As a private, first class, I remember you could have found more than 1 percent. This administration cannot do it.

Therefore, the responsiblity falls on you. I do not envy you that, but I am not going to say somebody up above told me to do it. We have had that excuse before. I think the National Science Foundation is facing a very serious crisis in what it is charged to do and what you are coming here and saying you are trying to do.

I am understanding and sympathetic, but there is a limit. I think someplace or other science and engineering are going to have to draw the line and say we will no longer be parties to this kind of mindless onslaught because a David Stockman, whom Mr. Roberts described as the one who got us into this Stockman recession, is working his will in this sensitive area.

I say that with all due respect and affection, Dr. Slaughter, but it is a very sorry performance that I see.

Thank you, Mr. Chairman.

Mr. **Walgren**. Thank you, Mr. Shamansky.

Mr. Brown?

Mr. BROWN. Mr. Chairman, I have no prepared opening statement. While I would like to defend the NSF budget which has been presented to us and even the section dealing with science and engineering education, I am afraid that peer pressure would make it impossible for me to do so, so I had better not say anything.

However, I am very pleased with the overall—I should not say very pleased—I am reasonably well satisfied, as the chairman has indicated in his own remarks, with the overall efforts made to preserve a satisfactory program in the Foundation, and I hope we can continue to improve on it.

Mr. WALGREN. Thank you, Mr. Brown.

Mr. Skeen?

Mr. SKEEN. Thank you, Mr. Chairman.

Despite what may have happened to you up to this point, Dr. Slaughter, welcome to the committee.

Other than that, Mr. Chairman, I would like to hear what Dr. Slaughter has to say, and we will leave the petty flogging till later.

Mr. WALGREN. Thank you very much, Mr. Skeen.

We do appreciate your being here, Dr. Slaughter and the other representatives of the National Science Foundation. Your written statements will, of course, be made a part of the record. You may proceed to summarize or present your testimony as you feel most proper.

[Biographical sketches of Drs. Slaughter, Langenberg, and Friedl follow:]

BIOGRAPHICAL SKETCH OF JOHN BROOKS SLAUGHTER, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. John Brooks Slaughter was confirmed by the Senate to be Director of the National Science Foundation on September 23, 1980. As Director, he is responsible for an agency charged with strengthening the national scientific research potential, with improving science and engineering education at all levels, and with increasing the interchange of scientific information among scientists in the United States and abroad. He is also responsible for establishment and implementation of numerous bilateral science agreements with foreign nations, and other major tasks related to science, engineering and technology. His responsibilities, carried out through an agency of seven major directorates, involve administration of an annual budget exceeding $1 billion and the annual award of 12,000 to 14,000 grants for research. Research programs are conducted in all fields of natural and social sciences and include major national and international science programs.

Before joining NSF Dr. Slaughter was Academic Vice President and Provost of Washington State University, Pullman, Washington.

Prior to his appointment to Washington State Universtiy, Dr. Slaughter had been Assistant Director of the National Science Foundation for Astronomical Atmospheric, Earth, and Ocean Sciences. In that position Dr. Slaughter was responsible for five NSF divisions—Earth Sciences, Ocean Sciences, Astronomical Sciences, Atmospheric Sciences and Polar Programs. The Directorate supports several major research programs such as the Global Atomospheric Research Program, the Ocean Sediment Coring Program, and the Arctic and Antarctic Programs. It also funds and administers a number of major national research laboratories.

Before assuming his position as NSF Assistant Director, Dr. Slaughter was Director of the Applied Physics Laboratory and Professor in the Department of Electrical Engineering at the University of Washington at Seattle.

As Laboratory Director since 1975, he was responsible for the direction and management of a research and development program in ocean and enviornmental sciences and engineering. He initiated new programs in energy resource conservation and development, geophysics, environmental acoustics and bioengineering at the Laboratory. Under his direction, the staff of the Laboratory, a leader in the fields of underwater acoustics, underwater vehicles and phyiscal oceanography, grew from 180 to 240.

BIOGRAPHICAL SKETCH OF DONALD N. LANGENBERG, DEPUTY DIRECTOR

Donald N. Langenberg was born March 17, 1932 in Devils Lake, North Dakota. He received his undergraduate education at Iowa State University, received the M.S. degree from the University of California, Los Angeles, and the Ph.D. degree from the University of California, Berkeley.

He joined the faculty of the University of Pennsylvania in 1960, where since 1967 he has been Professor of Physics. He currently also holds a secondary appointment as Professor of Electrical Engineering and Science.

Dr. Langenberg is married to the former Patricia Warrington, who is Assistant Professor of Statistics at Temple University. They have four children: Karen, 25, graduate student in physiology, University of Pennsylvania; Julie, 23, student in the School of Veterinary Medicine, University of Pennsylvania; John, 18, student at Yale University; Amy, 16, student at Lower Merion High School, Ardmore, Pennsylvania.

Dr. Langenberg's field is experimental condensed matter physics and materials science. His earliest research was concerned with the electronic properties and Fermi surfaces of metals and semiconductors. A major part of his research career has been devoted to the study of the phenomenon of superconductivity, particularly the Josephson effect and nonequilibrium superconductivity. He is perhaps best known for his work on the determination of certain fundamental physical constants using the AC Josephson effect. One of the consequences of this work was the development of a new type of voltage standard which has been officially adopted by the United States and by other nations. Dr. Langenberg is the author or co-author of approximately one hundred scientific articles and has edited several books.

Dr. Langenberg has held predoctoral and postdoctoral fellowships from the National Science Foundation, the Alfred P. Sloan Foundation, and the John Simon Guggenheim Foundation. In 1975, he was awarded the John Price Wetherill Medal of the Franklin Institute. He has been a visiting professor or researcher at Oxford University, the Ecole Normale Superieure, the California Institute of Technology, and the Technische Universitat Muchen.

BIOGRAPHICAL SKETCH OF ERNESTINE (MRS. HARRY L. LEVY) FRIEDL, ANTHROPOLOGIST

Born Cegled, Hungary, August 13, 1920; daughter of Nicholas and Ethel (Neudorfer) Friedl; came to U.S. 1922, naturalized 1927; married Harry L. Levy, September 27, 1942.

A.B., Hunter College, 1941; Ph.D., Columbia University, 1950.

Lecturer Brooklyn College, 1942–44; 1946–47; instructor Wellesley college, 1944–46; instructor Queens College, 1947–55, assistant professor 1956–60, associate professor 1960–64, professor 1965–74, chairman department of anthropology-sociology, 1964–68; executive officer Ph.D. program in anthropology City University New York 1969–70; chairman department of anthropology, 1973–1978, professor of anthropology 1973—, Dean of Arts and Sciences and Trinity College, 1980—. Duke University, Durham, North Carolina.

NSF grantee 1963–65; recipient Fulbright Research (Greece) award, also Research award Wenner-Gren Foundation, 1955–56.

Fellow American Anthropological Association (president 1974–75), Modern Greek Studies Association (executive committee 1975—), A.A.A.S.; fellow, American Academy of Arts and Sciences; member Society Applied Anthropology, American Ethnological Society (secretary-treasurer 1951–52, president 1967), Northeastern Anthropological Association (president 1970). Phi Beta Kappa. Member, National Science Board, 1979—.

Author: Vasilika, a Village in Modern Greece, 1962; Women and Men, An Anthropologist's View, 1975.

Home: 21 Stoneridge Circle, Durham, North Carolina 27705.

STATEMENT OF DR. JOHN B. SLAUGHTER, DIRECTOR, NATIONAL SCIENCE FOUNDATION, ACCOMPANIED BY DR. DONALD N. LANGENBERG, DEPUTY DIRECTOR, AND DR. ERNESTINE FRIEDL, MEMBER OF THE NATIONAL SCIENCE BOARD

Dr. SLAUGHTER. We are pleased to be here, Mr. Walgren, and I thank you for your opening comments that there are some strengths in the Foundation's budget.

Mr. Shamansky, I am impressed with your opening comment and concern. I also see the science and engineering education program as exceedingly important, but I will reserve an opportunity to respond. Let me point out that there is little difference between the words that I say and the beliefs that I hold concerning the importance of science and engineering education to this country, and I believe we will demonstrate that fact in our testimony.

Most importantly, we are pleased to present the Foundation's budget request to this committee today during this opening round of discussions. It is somewhat unfortunate that the scheduling of events for the next several days fails to provide us an ample opportunity to indicate convincingly to you that the National Science Foundation program is worthy and contains much more than just those aspects which are under continuing siege.

We must address those issues, of course, and I am pleased to have the opportunity in this forum to do so. But I would like to take a few moments, with your permission, to place them in the context of the total program of the National Science Foundation. We do have a budget in the neighborhood of $1 billion which will support some of the most exciting and important research contributing to the strength of this country that one can imagine in a single agency.

If you will indulge me a few moments, I would like to place the issues we will be discussing today and the issue so eloquently raised by Mr. Shamansky—it will be discussed later in the week—in the context of the framework of the National Science Foundation. But I would like first to introduce the lady on my right, the dean of the College of Arts & Sciences in Trinity College at Duke University, a member of the National Science Board, Dr. Ernestine Friedl, a noted researcher and anthropologist; and the gentleman on my left, the Deputy Director of the National Science Foundation, Dr. Donald N. Langenberg.

The fiscal year 1983 budget for the National Science Foundation is shaped within the context of the President's economic recovery program. We expended a considerable amount of energy this year, seeing that all program activities and priorities provide the largest possible return on the dollars invested in research to support the Nation's needs for future scientific and engineering knowledge. We believe that NSF's budget does provide a firm foundation for the realization of national goals, sustained real economic growth, enhanced national security, and an improved quality of life.

As usual, many individuals and groups helped us to develop the budget: the National Science Board, representatives from the academic and industrial research communities, and staff of the Office of Science and Technology Policy and the Office of Management and Budget.

The first question we asked in deciding what should be included in the budget was whether the programs were programs of excellence—excellence in both achievement and promise.

Second, we recognized that scientific breakthroughs often come from unexpected areas. Research in one area can lead to results in another. Therefore, we believe NSF programs should not be narrowly focused, but should provide a broad base of support across a wide variety of scientific and engineering disciplines, as the NSF organic act comtemplates.

Third, we believe there are important areas of science and technology with immediate importance to national goals of improving the economy, increasing productivity, and contributing to a stronger defense.

Finally, we are proud to identify a few important, high-leverage kinds of opportunities for expanding the Nation's scientific and engineering personnel base. In particular, we recognize that economic recovery is inextricably linked to bringing into the science and engineering technology base the skills and experiences of a large number of minorities and women in our society.

Fiscal year 1983 request for science and engineering in the Foundation's research budget calls for an increase of some $85 million to a new level of $1.0556 billion, an 8.7 percent increase. Included in that total are some budget transfers; consequently, the increase is not quite so large as it might seem at first glance.

The total includes, for example, $13.4 million transferred from the U.S. Coast Guard to the National Science Foundation for support of icebreakers in the Antarctic. There is also a $3.3 million item representing the minority institution's science improvement program which would be transferred to the National Science Foundation if the administration's plan to eliminate the Department of Education is completed.

If we exclude these budgetary transfers, the increase for NSF research and related activities amounts to about 7 percent, providing us the opportunity for real growth in some areas and maintenance of cost-of-living increases in others. Certainly there are some reductions, and we will be discussing them with the committee.

Nevertheless, I believe that the total increase, as you pointed out in your opening comments, does reflect the commitment that the administration has attached to supporting fundamental research and to maintaining the vitality and health of the Nation's research enterprise.

Within NSF's research budget, emphasis has been placed in the physical sciences, the earth sciences, and engineering. We believe that these areas represent the greatest opportunities for scientific advance and for making long-term contributions to the Nation's economic and defense goals.

In mathemathics and physical sciences, we request an increase of $25.8 million, or 9.5 percent above the figure for fiscal year 1982. Strong support, an increase of 14 percent, is provided for computer research because we believe that increasing the universities' capability in experimental computer science is an immediate and important responsibility of the Foundation.

We believe also that increases in support of microelectronics and communications research represent important areas to which the Foundation must respond. Consequently, we are including increased support in the budget for such research in fiscal year 1983.

In engineering we propose again, the greatest increase in any part of our budget, a 9.8-percent increase above the fiscal year 1982 plan, to a new level of $99.7 million. The engineering program will emphasize mechanical engineering and applied mechanics and electrical, computer, and systems engineering. We also will be addressing robotics, automated machine processes, fluidics, intelligent electronic systems, integrated optics, and a significant component of support in computer research. We are pleased to continue our commitment to engineering in this budget.

In the Earth sciences we have learned a great deal during the past decade. The deep sea drilling project has revolutionized our understanding of the evolution of the Earth. Many new discoveries have resulted from our understanding of plate tectonics, and we have seen new opportunities for understanding much more about the development of hydrocarbon deposits.

We have determined that the Earth sciences, particularly in the continental regions, deserve greater attention by the Foundation. Therefore, the budget request is increased by 17.8 percent for the Earth sciences.

As you know, NSF is responsible for managing the U.S. Antarctic program. During the past several years, we have had to defer some maintenance because of inadequate budgets for the Antarctic program. This year we are requesting an increase large enough to correct some of those deficiencies and to continue important research work in climate, geology, and oceanography in the Antarctic. The $13.4 million that I mentioned earlier for Coast Guard icebreaker support represents new funding by the Foundation to provide all of the support necessary for all of the resources required in the Antarctic program.

We have said before this committee several times that there is a serious problem in the Nation's universities and research laboratories stemming from the need for improved scientific and engineering research equipment and facilities. This year, NSF's budget shows an increase of 12.7 percent for expenditures to improve instrumentation in the university laboratories. We expect to spend $94.2 million during fiscal year 1983 to address that critical problem.

Mr. Chairman, your committee last year was quite concerned about the Foundation's fiscal year 1982 budget request for the social and behavioral sciences. That, of course, is the principal reason for this hearing today.

Let me say at the outset that the March 1981 request for the behavioral and social sciences in fiscal year 1982 totaled $21.1 million—$10.1 million for the social and economic sciences, and $1[illegible] million for the behavioral sciences. This committee, the National Science Board, behavioral and social scientists, and physical scientists throughout the country came together in an extraordinary effort to articulate clearly and strongly the importance of increased support in these sciences to the betterment of this country.

The administration responded, and the National Science Board in June directly addressed the issue as Dr. Friedl and I will discuss later today. The important result was the administration determination that increased funding was required for the behavioral and social sciences. In an unprecedented move, a 53-percent increase was added to NSF's budget for the behavioral and social sciences. The $21.1 million request was increased to $32.3 million before fiscal year 1982 began.

With the support of the administration, we determined that it made more sense to include those funds in the fiscal year 1982 budget rather than to put part of them into fiscal year 1982 and part into fiscal year 1983. NSF's request for fiscal year 1983 shows an increase of only $800,000 over the fiscal year 1982 figure, but that was largely because of a conscious decision to increase the $21.1 to $32.3 million in fiscal year 1982. I think the decision was correct. It provided us a better opportunity to maintain the momentum that could have been lost in the behavioral and social sciences.

Certainly I would not attempt to say that we have all the funding necessary to do the first-rate research emanating from the social and behavioral science community, but we are making a move to restore the funds needed to accomplish the important research in these fields. We will provide greater detail in response to your questions, of course, but we believe the behavioral and social science, not only are integral parts of the Foundation's effort but also that the program is funding quality research activities. We are pleased to be in a better position now to support them.

Mr. Chairman, you pointed out clearly, seconded by Mr. Shamansky—and I know by Mr. Brown—the importance of science and engineering education. Let me assure you that we feel that importance just as clearly at the National Science Foundation as you do here in the committee.

We are concerned about the reduced high school enrollments in science and mathematics. We are concerned about the reduced college admission requirements. We are concerned about the lack of appreciation that much of the country shows for elementary and secondary schoolteachers, so that it is difficult to attract the kind of teachers needed to educate young men and women.

We are concerned not only that there will be perhaps a shortage of skilled scientists and engineers 10 years from now, but also that there will not be a higher level of scientific and technological literacy among the people—a literacy needed for continued growth and productivity in this country.

We believe it is important that the National Science Foundation identify and pursue vigorously its role in this regard. We are proposing, and we will be discussing with you on Thursday, the establishment of a National Science Board Commission on Pre-College Education in Mathematics, Science, and Technology. The proposal represents an active step on NSF's part to take a lead role in helping to define a national agenda for mathematics and science instruction and achievement in this country. It will involve other Federal agencies, State, and local governments, professional associations in the private sector, and community groups. I will be proud to present the proposal to you in the discussions later this week.

Mr. Chairman, we are bringing before you a balanced budget, a strong budget. It provides the opportunity to fund significant research by scientists throughout this country, particularly in the natural sciences, the biological sciences, and the geophysical sciences. We believe it is a sound budget, consistent with the overall framework for the Nation's economic recovery and providing the opportunity to help address the important issues identified by the administration and by the Congress.

I would like now to turn the microphone over to Dr. Friedl for her comment concerning the National Science Board's role in addressing the critical issue of the behavioral and social sciences.

Dr. **Friedl**. Thank you, Dr. Slaughter.

Mr. Chairman and members of the subcommittee, it is a great privilege to be here today to talk about the social and behavioral sciences at the National Science Foundation.

When the budget was introduced last spring and it was clear that there was stress in the behavioral and social sciences budget, members of the Board decided to inform themselves on the social and behavioral sciences and on what the Foundation had done with respect to the social and behavioral sciences. So in April we began to hear with presentations by distinguished social and behavioral scientists who came to the Board meeting to describe for us the research going on in these fields. This was an impressive set of presentations, which then led the members of the Board to a renewed sense of the importance of the behavioral and social sciences to the welfare of this country.

After these presentations and as part of them, we asked the Director also to develop some materials on the history of behavioral and social sciences at the Foundation, on the history of research that had been done and was being continued at the Foundation, and on possible recommendations for major priorities in these fields.

While the Foundation staff was working on these matters, members of the staff and members of the Board talked at length to the behavioral and social science community to hear its primary concerns.

As a result of these activities, we had a considerable amount of information available for the June meeting of the Board. This was the meeting at which we were determined to make a statement about the social and behavioral sciences and to set priorities for the research activities we thought the Foundation should pursue.

We were successful at that June meeting. I may tell you it was rather dramatic, because after 2 days of discussion, we found that we could keep the members of the Board another 3 or 4 hours. And members stayed, so that we would develop a statement right at that meeting.

You have heard what the statement says. We stated again the responsibility of the Foundation for the maintenance of behavioral and social science research as one of its research fields. This was one of the statement's basic points.

We also stated clearly and unequivocally that we considered this kind of research on a par with other research being supported by the Foundation and that it was equally valuable to the national welfare.

We talked about the particular role of the National Science Foundation: What could the Foundation as an agency do that was different from what other Government agencies were doing with respect to the behavioral and social sciences.

We believed that the unique role of the Foundation was the enhancement of scientific capability in the development of tools of inquiry for the behavioral sciences; NSF was the major support for the social and behavioral sciences, in enhancing the objectivity of these sciences and in improving the quality of data collection and analysis.

In our view, it was this kind of support that led to progress in the development and refinement of tools, techniques, and capabilities of the social sciences. Without NSF support for this kind of work, the aspects of the social sciences that have been discovered to be extremely useful in a wide variety of activities in government and industry and in the schools—the improvement of social science data and of social science analysis—would not have been possible.

We reaffirmed our strong belief that a technologically based society needs the talents and skills of behavioral and social scientists, particularly to see how technological change is related to human change, or how human beings react to technological change. Systematic observation study, and analysis of that phenomenon are of vital importance, as we all know. They are among the interests of industries dealing with new techniques and new technologies. Government and the human population in general also are vitally interested in these factors.

We decided finally that support of the behavioral and social sciences should be continued, and that obviously the primary criterion would be the quality of research done by grantees of the National Science Foundation. We believed that the program must include and maintain the data bases begun with National Science Foundation funds—bases upon which a great many communities now rely.

We decided that it was important to improve and strengthen research methods, one of the primary contributions of grantees of the Foundation. We also decided it was vitally important to keep alive the opportunities for research that came out of the blue, as it were—that is, the kind of research that investigators in the behavioral and social sciences discovered would suddenly be creative, interesting, and valuable. We thought it important to maintain a window for that kind of research.

With these priorities set, we asked the Director of the Foundation to develop a statement for implementation of these particular guidelines.

I may say, before Dr. Slaughter tells you how the Foundation developed the implementation plan that members of the Board, are not all behavioral and social scientists. Only two of 24 members works in these fields.

Therefore, when I say that the National Science Board came to make a statement, to work at it hard and long, and to come to a conclusion last June, I am talking about people whose concerns, at least within the framework of science, are not primarily in their own scientific interest. Their concerns were clearly for the welfare of this Nation. It is in that spirit that I present to you the Board's statement on this matter and the Director's implementation statement.

Thank you.

Mr. **Walgren**. We will include a full text of the Board's statement at that point in the record, without objection.

Dr. **Friedl**. Thank you.

[Material to be supplied follows:]

STATEMENT ON NATIONAL SCIENCE FOUNDATION ACTIVITIES IN SCIENCE AND ENGINEERING EDUCATION AS ADOPTED BY THE NATIONAL SCIENCE BOARD AT ITS 228TH MEETING ON AUGUST, 20-21, 1981

The United States requires an educational system equal to its needs and opportunities in science and technology. The National Science Board is gravely concerned that the Nation is far less well prepared to meet the needs and challenges of the future than is necessary for it to maintain world scientific and technical leadership. In the words of James B. Conant, first Chairman of the National Science Board:

> ...in every section of the entire area where the word science may properly be applied, the limiting factor is a human one. We shall have rapid or slow advance in this direction or in that depending upon the number of really first class men [and women] who are engaged in the work in question.... 1/

The National Science Foundation (NSF) has specific responsibility under the National Science Foundation Act to "recommend and encourage...national policies for the promotion of...education in the sciences" and "to initiate and support... programs to strengthen...science education...at all levels." Thus the Foundation has a special role and responsibility in supporting the long-term development of a strong human resource base in science and engineering.

After a yearlong study beginning in June 1980, the Board has concluded that it must provide guidelines for a stable and well-focused NSF science and engineering education activity that can withstand the temptations of continual modification and proliferation of programs. It recognizes the need to focus on achievable goals with the resources necessary to attain them.

The National Science Board proposes a core of activities focused on people, especially those who will bear major responsibility for the future excellence of our scientific and technological enterprise. These activities will build the human resource base for science and engineering and express the Foundation's determination to encourage and assist all students, with particular determination to tap the underused talents of minorities and women.

1/Bush, Vannevar. Science--The Endless Frontier, July, 1945. 144 pp.

IMPLEMENTATION OF THE NATIONAL SCIENCE BOARD'S POLICY ON SCIENCE AND ENGINEERING EDUCATION AS ADOPTED BY THE BOARD AT ITS 228TH MEETING ON AUGUST 20-21, 1981

In the National Science Board's statement of August 20, 1981, concerning science and engineering education, it identified three major areas of activities for which the National Science Foundation has responsibility. In section I, the Board reaffirmed the Foundation's responsibilities for research-level education through a policy of conducting most of its research in institutions of higher education through the provision of predoctoral fellowships and for the monitoring of the quality and quantity of the human resource pool to meet national needs in science and engineering.

With regard to section II, the National Science Board requested the Director's help in identifying areas of national concern. One major task for the Nation is the reestablishment of a stronger base of secondary school graduates with appropriate science, engineering, and mathematics backgrounds from which to draw future generations of scientists, engineers, and technical people needed for a strong and innovative science and technology enterprise to bolster industry, the economy, and our defense. This requires building consensus among Federal agencies, state and local governments, and the private sector regarding such things as: (a) improved standards and requirements for college entrance and retention, high school graduation, and course achievement; (b) improved number and quality of secondary school teachers of mathematics and science; and (c) the creation of a greater sense of importance in scientific and technical education for individual and societal well-being.

Two other major tasks facing the Nation that can be identified now require similar attention and leadership effort. One is to enlarge the Nation's pool of trained scientific and technical talent by encouraging minorities and women to enter that pool. Another is to address the critical shortage the Nation now seems to be facing of computer scientists and certain types of engineers. National Science Board Special Commissions, blue-ribbon panels, internal task forces, and processes for the dissemination of information regarding the status of the science and engineering education system provide means for carrying out this role.

I recommend that the National Science Board consider as a first step establishing now a Special Commission to assist in the development of criteria for quality in science and engineering education. The Special Commission would consider such issues as college admissions and retention, high-school graduation requirements, and mechanisms for assuring high quality instruction in science and engineering.

Furthermore, the statement of the National Science Board required the Director and his staff to recommend to the Board specific selected high-leverage support described in section III of the statement. The National Science Foundation can provide support in selected areas where significant improvement in science and engineering education is possible with limited investment. Examples include: (a) materials and publications for science teachers in schools and colleges to convey advanced knowledge and new technology resulting from basic research and industrial technology; (b) recognition of excellence of both students and teachers; (c) building opportunities for interaction between science teachers and scientists and engineers in colleges, universities, and industry; and (d) regional resource centers to coordinate and integrate such activities as local needs assessment, in-service training, encouragement of science interests in minorities and women, and local leadership development. Emphasis should be on setting examples, testing prototypes, and providing incentives.

I shall provide further implementing plans at future meetings of the National Science Board.

John B Slaughter

John B. Slaughter
Director
National Science Foundation

Mr. **Walgren**. Thank you, Dr. Friedl.

Dr. Slaughter?

Dr. **Slaughter**. Thank you, Dr. Friedl.

Mr. Chairman, rather than go into great detail on the implementation plan, I would like to request that it be included with the Board's policy statement. I will simply say that the Board did ask me, with the staff, to develop an implementation plan for carrying forth the sense of the Board and addressing the critical issues in the behavioral and social sciences.

In response to the Board's charge, we chose to develop a plan that emphasized research in the behavioral and social sciences, recognizing that the quality of research accomplished in those areas was equivalent to the quality of any other area of research supported by the Foundation. What we would attempt to do would be to identify those research activities, both domestic and international, that would enhance the objectivity of the social and behavioral sciences, improve the quality of data collection in those fields, and provide critical analysis and interpretation of social and behavioral phenomena.

We chose three areas to pursue: maintenance and development of key national data bases, improvement and development of research methodologies and techniques, and investigator-initiated projects intended to strengthen the understanding of behavioral and social phenomena.

We developed these plans on two levels: (1) where there would not be significant growth in the budgets for the behavioral and social sciences; and, (2) where there could be greater depth in the research based upon larger increases in the funding.

Rather than go into those in detail, as I mentioned earlier, I would like to submit them to you for the record. And of course I would be happy to respond to specific questions in those areas.

Mr. **Walgren**. Did those inclusions include dollar amounts?

Dr. SLAUGHTER. No, not in the implementation plan; the dollar amounts were not included.

Mr. WALGREN. The implementation plan would be broken out, for example, under biological and behavioral and social science; it would have physiology, cellular——

Dr. SLAUGHTER. No, that would be in biology. These would be anthropology, archaeology, social sciences, economics, and psychology.

Mr. WALGREN. Would cognitive and linguistics be in the social sciences?

Dr. SLAUGHTER. Yes.

Mr. WALGREN. Perhaps we should include in the record at this point a display here for cross reference, which shows 1980 funding, 1981 funding, actual 1982 funding by the National Science Foundation, and the proposed 1983 funding, and the percent change by various categories that could be used to reference your plan.

[Material follows:]

NATIONAL SCIENCE FOUNDATION

Level of Funding for Selected
Directorates and Programs
1980 - 1983 (proposed)
(in million $)

	Actual 1980	Actual 1981	Actual 1982	Proposed 1983	% Change 1980 - 1983
RESEARCH AND RELATED ACTIVITIES	893.1	946.7	969.7	1,055.6	+18%
I Mathematical and Physical Sciences	227.0	256.5	272.9	298.7	+32%
II Astronomic, Atmospheric, Earth and Ocean Sciences	218.1	236.3	240.0	259.7	+19%
III Biological, Behavioral and Social Sciences	185.7	185.6	176.0	186.7	+0.5%
A. Physiology, Cellular & Molecular Biology	72.1	78.2	79.4	85.2	+18%
B. Behavioral and Neural Sciences (in part)					
1. Cognitive Science					
Memory and Cognitive Processes	2.6	2.4	2.2	2.3	-12%
Social and Developmental Psychology	3.3	2.6	1.5	1.6	-52%
(Applied Psychology)	1.4	1.1	**	**	
Linguistics	2.7	2.2	2.1	2.2	-19%
2. Anthropology	6.6	6.0	5.5	5.6	-15%
Subtotal	16.6	14.3	11.3	11.7	-30%
C. Social and Economic Science Division					
1. Economics and Geography					
Economics	12.2	9.4	6.3	6.4	-48%
Geography	1.6	1.2	0.7	0.7	-56%
2. Social Measurement and Analysis					
Sociology	3.9	3.0	2.2	2.2	-44%
Measurement Methods and Data Resources	5.0	3.9	2.9	3.0	-40%
History and Philosophy of Science	1.5	1.1	0.9	0.9	-40%
3. Political and Policy Sciences					
Political Science	3.6	2.9	2.1	2.1	-42%
Law & Social Sciences	0.9	0.9	1.1	1.1	+22%
Regulation and Policy Analysis	2.6	2.7	0.9	0.8	-69%
Decision and Management Science		(0.4)	0.5	0.7	
Subtotal	31.3	25.5	17.6	17.9	-43%

** absorbed into other departments

Mr. **Walgren**. Thank you, Dr. Slaughter.

Dr. **Slaughter**. Let me conclude, Mr. Chairman, by making one or two comments concerning the other area of your interest today, the scientific, technological, and international affairs programs of the Foundation. I will describe them in three different categories. The first includes programs in industrial science and technological innovation. There is no more often-discussed topic of concern in science today than the joint role of industry and the Federal Government in support of research.

The National Science Foundation has taken a lead in several programs, and I would like to mention two. The first is industry-university cooperative projects, in which NSF serves as a catalyst in bringing together industrial organizations and universities to discuss opportunities for cooperation on research projects. In 1983, $6 million is set aside for supporting research in those areas—$6 million that can be matched by another $6 million put up by disciplines from which might come a specific research project. Good research has resulted from these joint activities. Where the university normally provides researchers, the industrial organization can provide facilities, equipment, researchers, and in some cases, funds.

The other area is industry-university cooperative centers. These are normally established in universities. The Foundation provides the planning and early funding for the centers, and they are ultimately supported by an industry or a consortium of industries engaged in a particular area. Examples include the Catalysis Center at the University of Delaware, the Polymer Processing Center at MIT, and the Computergraphics Center at the Polytechnic Institute in New York.

We also have a program of small business research in which we propose to expend $5.5 million in 1983, for support of small business research activities.

The second category I would like to mention involves intergovernmental programs. In the past, these programs have been supported to aid the transfer of technology from Federal programs to State and local governments.

In fiscal year 1982, we decided to encourage the transfer of funding responsibility for those programs from the Federal Government to more support from local governments and industry. NSF's responsibilities should be more in coordinating and providing an information transfer service.

With the encouragement of many of the States, notably North Carolina, California, and New York, we saw that the State governments could pick up more of that responsibility, and they are. We can all take a great deal of pride in their effort.

The Foundation continues its interest and support of the liaison activities in this effort. NSF supports conferences, develops networks, and sees to it that demonstration projects are facilitated. The Foundation's support is largely in bringing together the various entities, rather than providing all the funding.

The third category I will mention is international programs. NSF's emphases in 1983 are largely in the bilateral arrangements between this country and other governments. We have some 30 or so such bilateral arrangements.

The increase in the budget request of about 9.1 percent is largely divided between support of bilateral agreements in Europe and bilateral agreement in the developing countries of Latin America.

We believe it is important to facilitate the opportunities for scientists in this country to interact with their colleagues in foreign countries. American science is strengthened by these arrangements, many of them informal, many of them simply an opportunity for researchers working on a common problem to come together and address it.

Mr. Chairman, I appreciate your providing us the opportunity to present our budget, particularly to set the context for the later discussions of those areas of greatest concern to you. Thank you very much.

[The prepared statement of Dr. Slaughter follows:]

STATEMENT OF

DR. JOHN B. SLAUGHTER
DIRECTOR, NATIONAL SCIENCE FOUNDATION

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
FEBRUARY 23, 1982

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE,

TODAY YOUR COMMITTEE IS BEGINNING THE FIRST OF THREE DAYS OF HEARINGS ON THE ADMINISTRATION'S PROPOSED FISCAL YEAR 1983 BUDGET FOR THE NATIONAL SCIENCE FOUNDATION. I AM PLEASED TO BE HERE AND WITH ME, AT THE TABLE, ARE DR. DONALD N. LANGENBERG, DEPUTY DIRECTOR OF THE NATIONAL SCIENCE FOUNDATION AND DR. ERNESTINE FRIEDL, DEAN OF ARTS AND SCIENCES AND TRINITY COLLEGE AND PROFESSOR OF ANTHROPOLOGY, DUKE UNIVERSITY, AND A MEMBER OF THE NATIONAL SCIENCE BOARD.

I KNOW THAT THE FOCUS OF YOUR HEARINGS TODAY IS ON THE SOCIAL AND BEHAVIORAL SCIENCES AT THE FOUNDATION AS WELL AS ON SEVERAL PROGRAMS THAT ARE LOCATED IN THE DIRECTORATE FOR SCIENTIFIC, TECH-

NOLOGICAL AND INTERNATIONAL AFFAIRS (STIA). WHILE I INTEND TO COMMENT ON THE SOCIAL AND BEHAVIORAL SCIENCES MATTERS IN MY FORMAL REMARKS, AND, SUBSEQUENTLY, TO RESPOND TO SPECIFIC QUESTIONS ON STIA PROGRAMS OF INTEREST TO THE COMMITTEE, I BELIEVE THAT IT IS IMPORTANT TO LOOK AT THE FOUNDATION, AND ITS BUDGET REQUEST, AS AN INTEGRATED WHOLE.

THIS IS A THEME WHICH I INTEND TO STRESS DURING THE COURSE OF THESE HEARINGS AND FOR THAT REASON, I WILL BEGIN OUR APPEARANCE BEFORE YOU BY PRESENTING AN OVERVIEW OF THE FOUNDATION'S BUDGET REQUEST FOR FY 1983 AND THE PRIORITIES, AND PROCESS, WHICH HAVE GONE INTO SHAPING IT. THIS, I BELIEVE, WILL SET AN APPROPRIATE CONTEXT FOR DISCUSSION OF THE SOCIAL AND BEHAVIORAL SCIENCES, THE PRIMARY FOCUS OF TODAY'S HEARINGS, AS WELL AS A CONTEXT FOR EXAMINING THE NSF SCIENCE AND ENGINEERING EDUCATION ACTIVITIES, SCIENTIFIC INSTRUMENTATION AND PROGRAMS FOR MINORITIES AND WOMEN AND FOR THE PHYSICALLY HANDICAPPED TO BE DISCUSSED IN SUBSEQUENT HEARINGS.

DEVELOPING THE BUDGET REQUEST

THE ADMINISTRATION'S PROPOSED BUDGET FOR THE FOUNDATION WAS DEVELOPED WITHIN THE CONTEXT OF THE PRESIDENT'S ECONOMIC RECOVERY PROGRAM. EVERY GROUP IN THE NATION, INCLUDING THE SCIENTIFIC AND ENGINEERING RESEARCH COMMUNITIES, WILL BENEFIT IF THESE CRITICAL ECONOMIC OBJECTIVES ARE REALIZED.

As part of the Foundation's contribution to the achievement of these objectives, all program activities and priorities were carefully reviewed to insure that those included in the Administration's request would provide the largest possible return on the dollars invested in terms of the Nation's future scientific and engineering knowledge base. This knowledge base, resulting in part from the research which NSF supports, will help provide a firm foundation for the realization of national goals in the decade of the 80's --sustained, real economic growth; enhanced national security; and improved quality of life.

Numerous groups and individuals have been involved in these assessments during the past nine months including: the National Science Board; representatives from the academic and industrial research communities who serve on various NSF advisory committees; the Foundation's management and professional staff; and representatives of the Office of Science and Technology Policy (OSTP) and of the Office of Management and Budget (OMB).

Several criteria were used in making these assessments. First, and foremost, emphasis was placed on excellence and promise. We asked ourselves: "Which areas of research, which NSF projects and programs, are of the highest quality and offer the most scientific promise?"

The second criterion reflects the fact that key science and engineering breakthroughs often come from unexpected quarters and lead to advances on broad fronts. Thus attention was given to the need to maintain a broad base of support across a wide variety of scientific and engineering disciplines.

Thirdly, certain fields of science and engineering have clear, more immediate potential for contributing to important national economic, productivity or defense goals. These fields were singled out for special emphasis.

Finally, an effort was made to identify a few, potentially high leverage opportunities for expanding the Nation's scientific and engineering personnel base. Next week, I shall be talking about the results of applying this last criterion in our assessment when I discuss our programs for increasing research career opportunities for women and minorities.

The FY 1983 Budget Request for Research Activities

The results of this extensive process of assessment are reflected in the Administration's request for FY 1983. Support of Research and Related Activities will increase from the FY 1982 Current Plan of $969.7 million to a total of $1,055.6 million, an increase of $84.9 million or 8.7 percent.

Included as part of this increase is $13.4 million, due to a transfer of responsibility for support of icebreakers in the U.S. Antarctic Program from the U.S. Coast Guard to the NSF, and a proposed transfer of $3.3 million from the Department of Education for

THE MINORITY INSTITUTIONS SCIENCE IMPROVEMENT PROGRAM IF THAT DEPARTMENT IS REORGANIZED, AS PROPOSED BY THE PRESIDENT. EXCLUDING THESE, THE INCREASE FOR RESEARCH AND RELATED ACTIVITIES IS A LITTLE OVER 7 PERCENT. THIS MEANS THAT, OVERALL, SUPPORT OF RESEARCH WILL INCREASE SIGNIFICANTLY, WITH SOME PROVISION FOR REAL GROWTH IN CERTAIN AREAS IN LINE WITH THE CRITERIA I MENTIONED EARLIER. THE INCREASE PROPOSED IN THE SUPPORT FOR RESEARCH, DURING A PERIOD OF BUDGETARY REDUCTIONS IN MANY FEDERAL PROGRAMS AND ACTIVITIES, REFLECTS THE IMPORTANCE WHICH THE ADMINISTRATION ATTACHES TO THE SUPPORT OF FUNDAMENTAL RESEARCH AND TO MAINTAINING THE VITALITY AND HEALTH OF THE NATION'S RESEARCH ENTERPRISE.

PHYSICAL SCIENCES AND ENGINEERING

WITHIN THE RESEARCH ACTIVITIES, PRIORITY HAS BEEN GIVEN TO THE PHYSICAL AND EARTH SCIENCES AND TO ENGINEERING. THESE ARE THE DISCIPLINES PRESENTING MANY OF THE GREATEST OPPORTUNITIES FOR SCIENTIFIC ADVANCE AND FOR MAKING LONG-TERM CONTRIBUTIONS TO NATIONAL ECONOMIC AND DEFENSE GOALS.

THE AMOUNT REQUESTED FOR THE MATHEMATICS AND PHYSICAL SCIENCES ACTIVITY IS $298.7 MILLION, AN INCREASE OF $25.8 MILLION OR 9.5 PERCENT ABOVE THE CURRENT PLAN FOR FY 1982. THIS REPRESENTS SOME REAL GROWTH FOR THESE FIELDS WHERE OPPORTUNITIES ARE GREATEST.

WITHIN THE MATHEMATICAL AND PHYSICAL SCIENCES ACTIVITY, STRONG SUPPORT IS PROVIDED ACROSS THE FULL SPECTRUM OF DISCIPLINES WITH AN

ADDITIONAL SPECIAL THRUST IN COMPUTER RESEARCH WHICH WILL RECEIVE AN INCREASE OF $3.6 MILLION OR 14 PERCENT OVER THE FY 1982 CURRENT PLAN. IN COMPUTER SCIENCE, DEVELOPING AN ADEQUATE LEVEL OF EXPERIMENTAL RESEARCH ACTIVITY AT UNIVERSITIES HAS BEEN IDENTIFIED AS AN ITEM OF HIGHEST PRIORITY IN THE PAST SEVERAL YEARS. THIS YEAR'S REQUEST IS A CONTINUATION OF THIS PRIORITY.

INDUSTRIAL EXPANSION INTO NEW TECHNOLOGIES AND PROCESSES USING COMPUTERS HAS CREATED A HEAVY DEMAND FOR NEW IDEAS AND TRAINED SCIENTISTS. THE DEMAND FOR BOTH HAS FAR EXCEEDED SUPPLY IN RECENT YEARS. FURTHERMORE, RECENT DEVELOPMENTS IN MICRO-ELECTRONICS AND COMMUNICATIONS HAVE OPENED UP EXCITING NEW RESEARCH OPPORTUNITIES IN INTEGRATED COMPUTER AND COMMUNICATIONS SYSTEMS. THE FOUNDATION IS RESPONDING TO THESE EXCITING OPPORTUNITIES AND ITS PROGRAM WILL PROVIDE SOME OF THE KNOWLEDGE AND EXPERIENCE BASE IN COMPUTER SCIENCE ON WHICH INNOVATORS AND MANAGERS CAN DRAW IN THE FUTURE.

SUPPORT FOR ENGINEERING RESEARCH TOTALS $99.7 MILLION, AN INCREASE OF $8.9 MILLION OR 9.8 PERCENT ABOVE THE FY 1982 CURRENT PLAN OF $90.8 MILLION (EXCLUSIVE OF A TRANSFER OF THE STRONG GROUND MOTION ARRAY PROJECT TO THE U.S. GEOLOGICAL SURVEY IN FY 1983). WITHIN ENGINEERING, SPECIAL EMPHASIS WILL BE GIVEN TO MECHANICAL ENGINEERING AND APPLIED MECHANICS, WHICH WILL INCREASE BY $2.3 MILLION OR 13.7 PERCENT AND TO ELECTRICAL, COMPUTER, AND SYSTEMS ENGINEERING WHICH WILL INCREASE BY $2.8 MILLION OR 11.1 PERCENT OVER THE CURRENT PLAN.

RESEARCH OPPORTUNITIES IN THESE AREAS ARE FILLED WITH POTENTIAL, BOTH FOR ADVANCING FUNDAMENTAL UNDERSTANDING OF MECHANICAL, ELECTRICAL AND COMPUTER SYSTEMS AND FOR ADDING TO THE KNOWLEDGE BASE IN SUCH AREAS AS ROBOTICS, AUTOMATED MACHINE PROCESSES, INTELLIGENT ELECTRONIC SYSTEMS AND INTEGRATED OPTICS. THESE ARE KEY TECHNICAL AREAS WHICH UNDERLIE PRODUCTION MANUFACTURING AND CONTROL IN AMERICAN INDUSTRY. THESE ARE ALSO AREAS, ALONG WITH COMPUTER SCIENCE, IN WHICH WE ARE CURRENTLY FACING FACULTY AND GRADUATE STUDENT SHORTAGES BECAUSE OF THE DEMAND AND HIGH SALARIES OFFERED BY INDUSTRY. BY PLACING SPECIAL EMPHASIS HERE, BY MAKING RESEARCH OPPORTUNITIES MORE ATTRACTIVE, WE HOPE TO ASSIST IN ALLEVIATING THIS CRITICAL PROBLEM.

EARTH SCIENCES

THE DEEP SEA DRILLING PROJECT (DSDP), USING CHALLENGER, OVER THE LAST 14 YEARS HAS VERIFIED THE PLATE TECTONICS THEORY, AND PRODUCED UNEXPECTED DISCOVERIES CONCERNING THE INTERACTION OF CRUSTAL PLATES. THE CHALLENGER PROGRAM IS CONTINUING DURING FY 1982 AND 1983, AND STUDIES ARE UNDERWAY THIS YEAR THAT SHOULD LEAD TO A DECISION CONCERNING AN ADVANCED OCEAN DRILLING PROGRAM.

THE DSDP HAS LAID THE GROUNDWORK FOR EXCITING NEW DISCOVERIES ON HOW THE EARTH'S CRUST WORKS ON LAND AS WELL AS ON THE OCEAN FLOOR. THE USE OF SEISMIC PROFILING TECHNIQUES IN THE APPALACHIANS AND OTHER AREAS HAVE REVEALED SUCH THINGS AS OVERTHRUST PLATES THAT MAY COVER HYDROCARBON DEPOSITS.

In recognition of the scientific and economic significance of research on the continental structure, the emphasis on earth sciences research within the Astronomical, Atmospheric, Earth, and Ocean Sciences (AAEO) Activity is continued with a proposed increase of $5.2 million or 17.8 percent over the FY 1982 Current Plan. The overall increase for AAEO is $19.7 million or 8.2 percent.

U.S. Antarctic Program

The Administration's proposed increase for the U.S. Antarctic Program in FY 1983, exclusive of the transfer of funds for icebreaker support, is $7.0 million or 10.6 percent. This will support increased costs required to maintain an active, first rate U.S. presence in Antarctica, provide for some deferred construction and equipment procurement and maintain strong research programs in the atmospheric, earth and ocean sciences in that region.

For FY 1982 and prior years, there has been only partial reimbursement to the Coast Guard for icebreaker services in the support of this program. Effective in FY 1983, the total operating cost of Coast Guard icebreakers, as it relates to the U.S. Antarctic Program, is being included in the Foundation request. This is another step in the consolidation of all the program costs in one agency and does not result in an increase in the total Federal budget.

RESEARCH EQUIPMENT AND INSTRUMENTATION

UNDERLYING THESE AND OTHER RESEARCH PROGRAMS IN THE FOUNDATION ARE CRITICAL, HIGH PRIORITY NEEDS FOR SELECTIVE, INCREASED INVESTMENT IN ADVANCED SCIENTIFIC AND ENGINEERING RESEARCH EQUIPMENT AND FACILITIES.

MUCH RESEARCH TODAY IS INSTRUMENT-DEPENDENT AND MANY ADVANCES CAN ONLY BE MADE THROUGH IMPROVEMENT OF THE QUALITY AND AVAILABILITY OF INSTRUMENTATION. IN THE COURSE OF ASSESSING NEEDS AND PRIORITIES THIS YEAR, EACH PROGRAM IN THE FOUNDATION EXAMINED ITS EQUIPMENT NEEDS. THIS RESULTED OVERALL IN AN ESTIMATED INCREASE IN OBLIGATIONS FOR RESEARCH EQUIPMENT IN THE PROPOSED FY 1983 BUDGET OF $10.6 MILLION OR 12.7 PERCENT. THIS INCREASE WILL BRING THE INVESTMENT IN RESEARCH INSTRUMENTATION TO AN ESTIMATED TOTAL OF $94.2 MILLION IN FY 1983.

INCREASES FOR INSTRUMENTATION IN THE VARIOUS PROGRAMS RANGE FROM 4.8 PERCENT FOR THE U.S. ANTARCTIC PROGRAM TO 23.5 PERCENT FOR ENGINEERING, REFLECTING THE RESEARCH NEEDS AND PRIORITIES OF DIFFERENT DISCIPLINES. DR. LANGENBERG WILL BE DISCUSSING THESE TRENDS IN MORE DETAIL FOR YOUR SUBCOMMITTEE NEXT WEEK AND WE SHALL ALSO BE SUBMITTING A STATEMENT AT THAT TIME ON THE SUBJECT FROM DR. LEWIS M. BRANSCOMB, CHAIRMAN OF THE NATIONAL SCIENCE BOARD.

SOCIAL AND BEHAVIORAL SCIENCES

AS THIS COMMITTEE KNOWS, WHEN THE ADMINISTRATION SUBMITTED ITS REVISED FY 1982 BUDGET REQUEST FOR THE FOUNDATION LAST MARCH, IT PROPOSED A LEVEL OF SUPPORT FOR THE SOCIAL AND BEHAVIORAL SCIENCES

WHICH TOTALED $21.1 MILLION - $10.1 MILLION FOR THE SOCIAL AND ECONOMIC SCIENCES, AND $11.0 MILLION FOR THE BEHAVIORAL SCIENCES, INCLUDING ANTHROPOLOGY. SINCE THAT TIME, AND AS AN INTEGRAL PART OF OUR OVERALL REVIEW OF PROGRAMS AND PRIORITIES IN PREPARATION FOR OUR FY 1983 BUDGET REQUEST, I AND THE NATIONAL SCIENCE BOARD HAVE HAD AN OPPORTUNITY TO REVIEW, THOROUGHLY, THE STATUS OF THE SOCIAL AND BEHAVIORAL SCIENCES AT THE FOUNDATION AND TO CONSIDER THEIR SIGNIFICANCE FOR AN IMPROVED UNDERSTANDING OF HOW HUMANS ACQUIRE AND USE KNOWLEDGE AND OF HOW HUMAN GROUPS, COMPLEX ORGANIZATIONS AND ECONOMIC AND SOCIAL SYSTEMS FUNCTION. THE INTERNAL REVIEW AND ASSESSMENT BY THE NSB OCCURRED IN PARALLEL WITH AN EXTRAORDINARY EFFORT ON THE PART OF THE RESEARCH COMMUNITY TO CLARIFY THE SIGNIFICANCE AND VALUE OF SOCIAL AND BEHAVIORAL SCIENCE RESEARCH AND ITS CONTRIBUTIONS TO THE ACHIEVEMENT OF NATIONAL GOALS AND TO COMMUNICATE THIS TO THE CONGRESS, THE EXECUTIVE BRANCH AND THE PUBLIC IN GENERAL.

AT THE CONCLUSION OF ITS REVIEW IN JUNE, THE NATIONAL SCIENCE BOARD ADOPTED A STATEMENT WHICH REAFFIRMED THAT THESE FIELDS ARE AN INTEGRAL PART OF THE SCIENTIFIC ENTERPRISE AND THAT NSF HAS A DISTINCTIVE ROLE TO PLAY IN ENHANCING THEIR SCIENTIFIC CAPABILITIES AND DEVELOPING THEIR TOOLS OF INQUIRY. IT STATED FURTHER THAT A BALANCED PROGRAM, WITH ADEQUATE RESOURCES, MUST INCLUDE MAINTENANCE OF LARGE DATA BASES, IMPROVEMENT AND STRENGTHENING OF RESEARCH METHODOLOGIES AND MAINTENANCE OF OPPORTUNITIES FOR INNOVATIVE, HIGH QUALITY INVESTIGATOR-INITIATED PROJECTS.

TWO SIGNIFICANT STEPS HAVE ALREADY BEEN TAKEN TO IMPLEMENT THE BOARD GUIDELINES. FIRST, FOLLOWING THE PASSAGE OF THE FY 1982 HUD-INDEPENDENT AGENCIES APPROPRIATION ACT (PL-97-101) AND THE PRESIDENT'S DECISIONS ON REDUCING THE ENACTED APPROPRIATION BY THE REQUIRED 4 PERCENT, WE HAVE SET A FUNDING LEVEL OF $32.3 MILLION FOR THE BEHAVIORAL, SOCIAL AND ECONOMIC SCIENCES IN FY 1982, AN INCREASE OF 53 PERCENT OVER THE AMENDED MARCH REQUEST OF $21.1 MILLION. AN ADDITIONAL INCREASE OF $800,000 IS REQUESTED FOR THESE SCIENCES IN FY 1983 TO BRING THEM TO A TOTAL OF $33.1 MILION -- $17.8 MILLION FOR THE SOCIAL AND ECONOMIC SCIENCES AND $15.4 MILLION FOR THE BEHAVIORAL SCIENCES.

SECONDLY, WITHIN THE OVERRIDING CONSIDERATION OF INTRINSIC MERIT AND SCIENTIFIC QUALITY, PRIORITY IS ASSIGNED TO RESEARCH THAT WILL:

- ENHANCE THE OBJECTIVITY OF THE SOCIAL AND BEHAVIORAL SCIENCES;
- IMPROVE THE QUALITY OF DATA COLLECTION; AND
- PROVIDE CRITICAL ANALYSIS AND INTERPRETATION OF SOCIAL AND BEHAVIORAL PHENOMENA.

WITHIN THE TOTAL REQUESTED AMOUNT FOR FY 1983, THE RESEARCH PROGRAMS IN THE SOCIAL AND BEHAVIORAL SCIENCES ARE BALANCED AMONG THREE TYPES OF ACTIVITIES: MAINTENANCE AND DEVELOPMENT OF KEY

NATIONAL DATA BASES; IMPROVEMENT AND DEVELOPMENT OF RESEARCH METHODOLOGIES; AND INVESTIGATOR - INITIATED PROJECTS FOR FUNDAMENTAL RESEARCH.

SCIENCE AND ENGINEERING EDUCATION

LET ME TURN FINALLY, TO THE FOUNDATION'S BUDGET REQUEST IN FY 1983 FOR SCIENCE AND ENGINEERING EDUCATION.

IT IS GENERALLY RECOGNIZED THAT WE HAVE A PROBLEM IN THE LEVEL AND QUALITY OF EDUCATION AVAILABLE TODAY IN SCIENCE AND MATHEMATICS EDUCATION IN THE NATION'S PRIMARY AND SECONDARY SCHOOLS. THERE IS ALSO EVIDENCE OF REDUCED HIGH SCHOOL ENROLLMENTS IN MATHEMATICS AND SCIENCE COUPLED WITH REDUCED COLLEGE ADMISSIONS REQUIREMENTS. THIS SITUATION HAS LONG-RUN IMPLICATIONS FOR THE AVAILABILITY OF SUFFICIENT NUMBERS OF SKILLED SCIENTISTS AND ENGINEERS TO MEET OUR FUTURE NATIONAL NEEDS.

THE PROVISION OF EDUCATION, FROM THE HIRING OF TEACHERS TO THE CHOICE OF CURRICULA, IS MOST CLEARLY AND APPROPRIATELY A RESPONSIBILITY OF STATE AND LOCAL GOVERNMENTS. THE FOUNDATION'S PRIORITIES LIE IN GRADUATE EDUCATION AND TRAINING AS THEY RELATE TO RESEARCH. BECAUSE OF THIS, OUR FY 1983 BUDGET REQUEST PROVIDES FOR GRADUATE FELLOWSHIPS AND STIPENDS FOR GRADUATE RESEARCH ASSISTANTS IN PROJECT AWARDS. IT ALSO PROVIDES FOR MONITORING AND EVALUATING PERSONNEL TRENDS AND THE STATUS OF GRADUATE SCIENCE AND ENGINEERING EDUCATION IN THE NATION AND FOR MAKING THIS INFORMATION GENERALLY AVAILABLE.

THE ADMINISTRATION'S REQUEST THIS YEAR FOR SCIENCE AND ENGINEERING EDUCATION IS FOR $15.0 MILLION TO SUPPORT 1,390 NEW AND CONTINUING NSF GRADUATE FELLOWSHIPS AND MINORITY GRADUATE FELLOWSHIPS. THIS WILL KEEP THIS PROGRAM ACTIVITY LEVEL WITH THE FY 1982 CURRENT PLAN. WE ESTIMATE THAT AN ADDITIONAL 9,000 GRADUATE STUDENTS WILL RECEIVE SUPPORT AS RESEARCH ASSISTANTS ON NSF-FUNDED PROJECTS IN SCIENCE AND ENGINEERING, DEMONSTRATING THE BREADTH OF OUR SUPPORT ACROSS ALL DISCIPLINES AS WELL AS THROUGH THE PRESTIGIOUS FELLOWSHIP ACTIVITY.

IN ELEMENTARY AND SECONDARY EDUCATION, NSF CAN PLAY AN IMPORTANT AND CATALYTIC ROLE BY HELPING TO IDENTIFY CERTAIN CRITICAL NEEDS, PROVIDING INFORMATION ON THEM AND ENCOURAGING SCIENTIFIC AND PROFESSIONAL SOCIETIES, ACADEMIC INSTITUTIONS, STATE AND LOCAL GOVERNMENTS, PRIVATE INDUSTRY, AND OTHER FEDERAL AGENCIES TO MEET THE CHALLENGES OF EARLY PREPARATION FOR RESEARCH CAREERS IN SCIENCE AND ENGINEERING.

THE POTENTIAL SIGNIFICANCE OF THIS ROLE IS UNDERLINED BY RECENT ACTIONS TOWARD THE ESTABLISHMENT OF THE NATIONAL SCIENCE BOARD COMMISSION ON PRE-COLLEGE EDUCATION IN MATHEMATICS, SCIENCE AND TECHNOLOGY. THURSDAY, DR. BRANSCOMB WILL BE WITH ME TO DESCRIBE, FOR THE COMMITTEE, THE GENERAL ROLE THE NATIONAL SCIENCE BOARD HAS PLAYED THIS YEAR IN SETTING THE OVERALL BUDGET STRATEGY FOR FY 1983 AS WELL AS ITS SPECIFIC ROLE IN REVIEWING SCIENCE AND ENGINEERING EDUCATION AT THE FOUNDATION AND THE ESTABLISHMENT OF THIS COMMISSION.

SUMMARY

WHAT I HAVE TRIED TO DO THIS AFTERNOON IS TO SET THE OVERALL BUDGETARY CONTEXT FOR THE THREE DAYS OF HEARINGS WHICH YOUR COMMITTEE IS HOLDING ON SELECTED FOUNDATION PROGRAMS AND ACTIVITIES. I APPRECIATE THIS OPPORTUNITY AND I HOPE THAT THIS WILL PROVIDE YOU WITH A BROAD FRAMEWORK FOR ASSESSING THEM AND FOR UNDERSTANDING THE PRIORITIES AND ASSUMPTIONS ON WHICH THEY ARE BASED

THE FOUNDATION'S PROPOSED BUDGET WAS DEVELOPED WITHIN THE CONTEXT OF THE PRESIDENT'S ECONOMIC RECOVERY PROGRAM. ALL PROGRAMS AND ACTIVITIES WERE REVIEWED TO INSURE THAT THOSE INCLUDED WOULD PROVIDE THE LARGEST POSSIBLE RETURN ON THE DOLLARS INVESTED. THE BALANCE OF SUPPORT LEVELS AND ACTIVITIES ACROSS THE FOUNDATION BUDGET REQUEST REFLECT THE RESULTING JUDGMENTS OF NUMEROUS GROUPS AND INDIVIDUALS ON RELATIVE SCIENTIFIC MERIT AND OPPORTUNITY AND ON POTENTIAL CONTRIBUTIONS TO NATIONAL GOALS.

THE 7 PERCENT INCREASE REQUESTED FOR RESEARCH AND RELATED ACTIVITIES DURING A PERIOD OF BUDGETARY REDUCTIONS IN MANY FEDERAL PROGRAMS REFLECTS THE IMPORTANCE WHICH THE ADMINISTRATION ATTACHES TO THE SUPPORT OF FUNDAMENTAL RESEARCH. WITHIN THIS OVERALL INCREASE, PRIORITY HAS BEEN GIVEN TO THE PHYSICAL AND EARTH SCIENCES AND TO ENGINEERING.

WE HAVE TAKEN SOME SIGNIFICANT STEPS TO FOCUS AND CLARIFY THE FOUNDATION'S ROLE IN THE SOCIAL AND BEHAVIORAL SCIENCES AND TO PRO-

VIDE A SUBSTANTIAL INCREASE IN FY 1982 IN SUPPORT OF THEM OVER THE ADMINISTRATION'S REQUEST LAST MARCH WITH A SMALL ADDITIONAL INCREASE PROPOSED IN FY 1983. I BELIEVE THIS WILL PUT THEM ON A NEW, FIRM FOOTING IN FY 1983, PROVIDING THEM WITH A SOLID BASIS FOR IMPLEMENTING THE GUIDELINES PROVIDED BY THE NATIONAL SCIENCE BOARD.

FINALLY, THE BUDGET REQUEST FOR SCIENCE AND ENGINEERING EDUCATION IN FY 1983 IS LIMITED TO THE SUPPORT OF GRADUATE FELLOWSHIPS. HOWEVER, AS DR. BRANSCOMB AND I WILL BE DISCUSSING ON THURSDAY, WE BELIEVE THE NEWLY FOUND NSB COMMISSION ON PRE-COLLEGE EDUCATION IN MATHEMATICS, SCIENCE AND TECHNOLOGY OFFERS AN EXCITING OPPORTUNITY FOR THE FUTURE.

THANK YOU.

Mr. WALGREN. Thank you very much, Dr. Slaughter, for that presentation.

I would like to recognize Mr. Gregg for an opening statement, and then we will go to questioning. I just want to give him an opportunity, along with Mr. Weber, to make any initial comments, and then I want to recognize Mr. Brown, because he came first.

Mr. GREGG. I think Mr. Brown should be recognized first anyway, since he is the more senior, knowledgeable, and eloquent member of the committee.

I would like to keep the record open for an opening statement, which I will be submitting at a later time.

[Material to be supplied follows:]

Opening Statement
of
Congressman Judd Gregg

Mr. Chairman: Research in science and engineering is recognized as an important investment in nation's future. The development of new technology and the training of future scientists and engineers is the key for reinvigorating and maintaining the economy as well as the basis for re-establishing America's competitive position in international trade.

The overall FY '83 budget proposed for NSF seems to be good. The increases proposed for direct support of research, while not as large as might be desired in better economic times, seem to demonstrate a committment by this Administration to the development and maintenance of a strong scientific community.

Unfortunately, this effort seems to be limited to the development of the knowledge base without adequate attention to the development of the science and engineering manpower to utilize this knowledge base.

Support for graduate students is laudatory but it does not address the long-range problem. It appears that the real problem occurs much earlier in the educational process. The poor quality of training in fundamental science and math at the pre-college level is devastating the pool of talented students to be drawn into science and engineering at the college level. A large percentage of the secondary school science and math teachers are not properly trained to adequately present the necessary material; and those who are well trained are being lured away from the profession by higher industrial salaries.

These problems in secondary education are even more disconcerting when viewed in the context of the recent announcement by NSF of the elimination of the Science and Engineering Education Directorate. The proposed Office of Science, Education, and Personnel and the Commission of Pre-college Education in Mathematics, Science and Technology will not be sufficient for the needs of science education in this country.

In order to rectify these deficiencies, I plan to propose measures designed to upgrade the scientific competence of secondary school science and math teachers and enrich the education of students in these areas.

Mr. **Walgren**. Mr. Weber?

Mr. **Weber**. That is fine with me.

Mr. **Walgren**. Also, I would like to recognize Mr. Lundine for any general comments.

Mr. Brown?

Mr. **Brown**. Dr. Slaughter, I caught a phrase in your opening statement. I understand what you were saying, but I wonder if you would not want to reconsider it. You said you brought us a balanced budget. You should distinguish what you mean by balanced as between disciplines and as to whether it fits in with an overall balanced budget.

Dr. **Slaughter**. Mr. Brown, I certainly did not mean it in an economic sense.

Mr. **Brown**. OK.

Dr. **Slaughter**. I meant to say that we explored the budget carefully this year and thought about it in the context of the criteria I established—excellence, national goals, constraints upon productivity, and economic recovery.

Mr. **Brown**. We will not belabor that point.

There were one or two areas, minor, but still of considerable importance to some members of the committee, that I would like to have you comment on just briefly, if you would.

One of the programs which appears to be disappearing is the various efforts to incorporate within the Foundation components of use to the handicapped community. There were several elements in prior budgets in that area. All of these seem to be, as far as I can discern, eliminated in the budget that you are bringing to us.

I can understand how this would be classified as a marginal area, and you might want to eliminate it as a line item, but can you describe to us what has happened and what your philosophy is toward programs that would provide scientific and technological focus on the needs of the handicapped?

Dr. **Slaughter**. Mr. Brown, I wonder if you would allow me to respond by submitting for the record a better report on that issue than I could provide at this time. The Foundation has pursued several activities in that regard; some activities in the engineering directorate are concerned with aid to the handicapped. But I would like to develop a report in more detail.

Mr. **Brown**. I wish you would, and we can explore it more later.

Mr. **Brown**. In the international field, I am interested in what the numbers are with regard to the program, and I presume that that is somewhere in the material that we either have or you can provide to us.

I am specifically concerned with what I understand is a high level policy decision to terminate the funding for IIASA. I would like to have you comment on that and if you can, without breaching your responsibilities to the administration, indicate how high a level of decision that was.

Dr. **Slaughter**. We determined, when the fiscal year 1982 levels were established, that NSF could not support both a full range of bilateral activities—particularly where we thought joint activities with foreign countries were important—and the international organizations.

As you know, there are really two major international organizations. One is IIASA, as you have mentioned. The other is the International Council of Scientific Unions [ICSU]. We decided to support ICSU through levies on each of NSF's research directorates, but the $2 million price tag associated with IIASA was not something that we could easily absorb in the budget. We determined that it would not be possible for us to continue that support indefinitely.

Consequently, we recommended to the National Academy of Sciences that it either discuss with IIASA a reduced United States support for IIASA or pass the word that it would be necessary for NSF to end its support. We did make a conscientious effort to obtain support from other agencies. Although many said IIASA was important, we did not find anyone willing to aid in sharing the cost of IIASA support.

Since that time, Mr. Brown, considerations other than the fiscal ones have appeared. Those considerations have been escalated to a high level in the Government, much higher than the level of the Director of the National Science Foundation.

Mr. **Brown**. If it should prove possible to find other agencies who might be interested and have the funds to support it, what you are saying is that it would still be contrary to the administration's policy to proceed with support for it.

Dr. **Slaughter**. I do not know that the administration has formulated a firm policy. The action of the United States in the IIASA situation is still undergoing review. I am just saying that financial support in not the only consideration.

Mr. **Brown**. All right. Let me just dwell momentarily on the interrelated issues of support for the social sciences and support for science education. It seems to me that what you have done in one sense is to look at two programs which were under threat and decided to save one of them and scrap the other, and to improve the quality of the one that you saved in the process.

If I accepted the hypothesis that you need to scrap one, I would commend you for that decision. I appreciate the focus that you have indicated on the social sciences. I still regret that the level of funding is really not proportionate to the importance of the field, in my opinion, but I regret even more the fact that it is necessary to drop the program of improving mathematical, scientific, and technical education in the process.

I recognize that we will discuss this further later and that you are proposing some new initiatives. Again, I commend you for that; they need to be explored. But the point that I really wanted to bring out and possibly ask you to comment on is this:

These two fields really are interrelated. There are close connections between the quality of our scientific and technical education and our support for science in general and social science in particular, and much of the quality of teaching is based upon social science research.

I am wondering if, within the framework of the commission which you are proposing, there could be some way of encouraging this recognition of interrelationship so that we could have some effort made at enhancing the quality of science education through the initiative and leadership of those in the social sciences.

I am thinking particularly of educational psychology and others who have an input into this field, so that we can see some hope for enhancing this area of scientific competence and public scientific literacy in some way that I do not perceive right at the present time.

Dr. **Friedl.** One of the areas of research that the behavioral and social sciences are continuing to fund is cognitive science. Cognitive science has already developed, through its research, a set of ideas important to learning theory and the understanding of how people learn.

By funding cognitive science, the Foundation is actually contributing to science education, because it is developing the basic research and the basic ideas that are then going to be useful for improving our methods of teaching. The question, of course, is how do you connect the two, but at least we hope that we will be able to do so. It is through this kind of research—in memory and learning—and in social and developmental psychology that we are contributing substantially to science education.

Mr. **Brown.** Possibly we can explore that more in the additional hearings.

Dr. **Slaughter.** Mr. Brown, I regret that from examining the budget and listening to our testimony you conclude that we have chosen to support the one and not the other. I regret it, because I value your judgment of these programs. Since it is important to recognize the complexity of this situation, I am looking forward to the opportunity to explore it in depth with you.

Mr. **Brown.** I do not think the Congress and this committee would have any objection to exploring new routes to the improvement of science and engineering mathematical education in this country, the improvement in the quality of teaching, the motivation of the young, and a whole range of things which need to be done, and which we obviously have not done all that well.

In fact, I would think we would want to encourage that, but we need to have some feeling that there is a focus of positive leadership being given to that at the Federal level and that it is not being neglected on the basis that it is not important. It is important, and it should not be neglected. We need to merely focus on how to achieve those goals in more sophisticated ways, it seems to me, than we perhaps have done in the past.

I yield back the balance of my time, Mr. Chairman.

Mr. **Walgren.** Thank you, Mr. Brown.

I think Mr. Gregg is next.

Mr. **Gregg.** Thank you, Mr. Chairman.

Dr. Slaughter, I am interested, as Congressman Brown was, in this education area. I think there is a lot of interest in this committee in the education area on the minority side as well as the majority side. We are looking for an original approach to how we educate our children in science. I certainly hear it in my district, especially at the secondary level.

So I am concerned about the cuts in the science education area, and I am also concerned about the decision to eliminate the directorate. I take it we are going to take all of this up on Thursday, and you are going to feel more comfortable discussing it then than now?

Dr. **Slaughter**. I will be happy to discuss it at your pleasure. I would be happy to answer any questions you might have, if you wish.

Mr. **Gregg**. Just in preparation for Thursday maybe, can you give us the background as to the decision on the directorate?

Dr. **Slaughter**. In addition to budgetary constraints, there are also staffing implications associated with the decisions in any program.

In the Science and Engineering Education Directorate, the staff is expected to decrease from 80 persons at the beginning of the fiscal year to about 10 persons at the end of the fiscal year—as a result of the budget reductions. Ten persons is hardly an adequate number to staff a directorate.

Part of the responsibilities of any manager is to determine how best to use his resources. After expending a great deal of energy and consulting with my staff and others I decided that a more efficient way would be to maximize the effectiveness of those 10 persons in addressing some of the ongoing and newer issues in science and engineering education. Some of the less critical activities are to be done in other parts of the Foundation.

It made sense to use more effectively the talents of those 10 persons by disestablishing the directorate—which would be a directorate in name only—and to establish an office reporting directly to me. With such an office, we would have an opportunity to do a better job of managing the current and new activities; addressing some of the critical issues that Mr. Brown has just outlined.

Mr. **Gregg**. Of course I can understand your desire to manage in these hard times. I think you are to be commended for taking affirmative management decisions and trying to lead your agency where you think it should go. However, do you not have budget authority for all 65 staff positions?

Dr. **Slaughter**. No, the Science and Engineering Education Directorate's funding comes from a different appropriation than the funding for other parts of the Foundation.

The funding for NSF staff, which comes out of our budget setaside for programs, can be used only for the total number authorized by the Office of Management and Budget, much in the same way that OMB provides a funding figure.

As a result, I must meet certain staffing levels at the end of fiscal year 1982. Indirectly, the requirement applies to the level of staffing provided for science and engineering education in the Foundation. That is where the number 10 came from.

Mr. **Gregg**. I guess that, rather than getting into specifics now, I will wait until Thursday.

Getting into the philosophy of it, looking down through these various areas, very few of them deal with actual hands-on educational activity. Is that correct—from my assumption?

Dr. **Slaughter**. I am not sure that I understand your question, Mr. Gregg.

Mr. **Gregg**. Mathematical and physical sciences—that is mostly people applying for grants to do specific scientific projects.

Dr. **Slaughter**. Those are largely research projects.

Mr. **Gregg**. Except to the extent that there was a graduate student involved who was being educated by the person who got the grant, there would not be hands-on direct educational activity?

Dr. **Slaughter**. At the graduate education level there would be. All of these are research projects involving equipment and research instrumentation, but activities at the secondary school level, for example, are not supported, and that is one of the issues we have been discussing.

Mr. **Gregg**. That would be true of all the different disciplines, other than the science and education?

Dr. **Slaughter**. That is correct.

Mr. **Gregg**. I take it then—and I am sure this is old ground which somebody has gone over before this—that the basic thrust of the National Science Foundation is that you are interested in pure science and how to move the issue of scientific knowledge along, versus educating the development of scientists.

Dr. **Slaughter**. No, we have a responsibility in both areas. Our charter clearly sets that forth. NSF's primary responsibility is scientific research and education, and we are maintaining support for some 9,000 graduate students through research grants, in addition to the 500 new students who will be supported by graduate fellowships—about 1,500 overall. There is a significant education component in the total program.

The Science and Engineering Education Directorate had been doing other kinds of work that no longer will be supported by a specific program. That work included activities at the precollege level and activities aimed at public understanding of science. But NSF research programs and the education coupled with them will continue.

Mr. **Gregg**. You have got a limited pie, obviously, to work with, and you have made your decisions as to how you are going to cut the pie, but basically you have decided that no one piece of the pie is going to be used for education at the secondary level. I assume that is because you just do not have the resources; is that right?

Dr. **Slaughter**. Yes. As you know, the administration has been concerned. In fact, the administration came into office with a concern about the Federal role in education. That concern is manifested clearly by the decision on the part of the administration to eliminate the Department of Education.

It is not surprising that that concern would be extended to the program of the National Science Foundation. The resources for science and engineering education are simply the $15 million requested for graduate fellowships. No other funds have been allocated by the Office of Management and Budget specifically for education.

Mr. **Gregg**. Independent of the administration's philosophical position, I take it it is the position of the National Science Foundation that you just do not have the money to get into secondary school activities.

Dr. **Slaughter**. At this point, we do not have adequate funds to get into a major program. The purpose of the commission that I mentioned would be to identify ways in which the National Science Foundation, with others, can play an effective and appropriate Federal role but one which strengthens the capabilities of the State and local governments where the significant responsibility resides.

Mr. **Gregg**. Just preempting the commission's decision process, do you have any thoughts on how that could be done?

Dr. **Slaughter**. Yes, I have some definite thoughts. Would you like me to go into those today?

Mr. **Gregg**. Yes, I would be interested in those.

Dr. **Slaughter**. We need to focus early on the problems of teacher education in the country. Few institutions today—very few of our colleges of education today—are training teachers prepared to go into the classrooms. The numbers are somewhat alarming. With 1,500 school districts, for example, we have only about 10,000 high school physics teachers for the entire country. This is the kind of thing we need to focus upon.

We also should be concerned with and help set some standards for the way in which schools establish the requirements for teacher preparation.

But we should not be in the business of identifying a curriculum for local school districts. On the other hand, we should make certain that we bring to bear the best minds in the development of a curriculum. We should assist local school districts in addressing those problems.

We also need to see if we can assist industry to play an important role, perhaps through tax incentives allowing instruments to be provided for instruction in the schools. It is possible now to think of how computers can be used in a classroom. That we have not done so, effectively, up to now represents a shortcoming in the educational system.

We should be trying to involve all who can help to improve the achievement level and instruction in the classroom. We should not be dictating activities. We should be trying to facilitate the efforts of others and trying to identify a meaningful and appropriate Federal role. These are some of the items that I think might be important.

Mr. **Gregg**. Thank you very much.

Mr. **Walgren**. Thank you, Mr. Gregg.

Mr. Lundine?

Mr. **Lundine**. I guess I would like to ask both you and Dr. Friedl to comment on this observation: The Biological, Behavioral, and Social Sciences Directorate will indeed experience a small increase over the fiscal year 1982 level of funding under the administration budget. The bulk of this will go to the biological sciences.

The social and economic sciences under the directorate, on the other hand, according to my calculations, experience almost a 50-percent decrease in funding from 1981 to 1983 under your proposals.

Given the fact that the NSF is a basic source of research in the social sciences, how can that level of decrease be justified?

Dr. **Slaughter**. Mr. Lundine, I will respond in the same way as the representative of the Office of Management and Budget.

Mr. **Lundine**. I have heard him. I am more interested in hearing you, quite frankly.

Dr. **Slaughter**. Let me give you the appropriate response. The decision to cut the behavioral and social sciences as deeply as they were cut in fiscal year 1982 was a mistake. The administration recognized the error in midyear and proposed an increase. That increase was not adequate to restore the level of funding, but it brought back 53 percent.

Even though the cuts were more severe than the administration, upon reflection, felt was appropriate, it was not possible within the total budget of the Foundation to restore enough funding to produce an increase for the social and economic sciences.

However, it is possible now to reconstruct some of the behavioral and social sciences budget, particularly in those areas concerned with quality research programs of the type that I described earlier in the three areas where NSF would provide some of the funding necessary for the forefront kind of scientific research in the behavioral and social sciences.

The cut cannot be justified on its merits, and I will not try to justify it. I simply say that we are trying to bring it back to a level more consonant with the total research support at the Foundation.

Mr. **Lundine**. I appreciate your relative candor under the difficulties of testimony and so on. I would like to go on, and then I would like to ask Dr. Friedl to comment on both questions.

Last fall I was given by the chairman the interesting assignment of being allowed to chair 6 days of hearings on human factors affecting innovation and productivity. Out of those hearings, where we heard extensively from business, labor, and university sources in the United States and from other countries, I became convinced that we need to encourage greater university-industry cooperation in social science research as well as in the physical sciences.

It seems to me there is also a need to do a little more in-depth, maybe participative, research, into the workplace, to better understand the interaction between technology and human factors.

Could any program of that type conceivably be accommodated either in your Biological, Behavioral, and Social Sciences Directorate or as an additional element in your industry-university cooperative program?

Dr. **Slaughter**. The answer to your question is yes. It could be accommodated within the Foundation in both cases you mentioned.

Those projects, Mr. Lundine, are investigator-initiated. We respond to good proposals that come in from most of the science communities. If such a proposal were made, of course, we would examine it for its merit for support. When we receive a good proposal, it is very much in keeping with the Foundation's responsibilities to support such a program.

Mr. **Lundine**. Dr. Friedl, did you want to comment?

Dr. **Friedl**. With respect to the size of the budget, Dr. Slaughter has comments. The only other point to be made is that, insofar as negotiations on budget can be construed as political activities, we are all cultivating the art of the possible, and that is essentially what has driven this budget.

The other point that you make about our developing the relationship between human factors and technology is certainly one of the primary concerns of the Foundation. I am convinced that, under the rubric of sociology, political science, and decision in management science, these are all parts of the normal research activities in the behavioral and social sciences. Any proposals that are relevant to this issue can fit into a number of these research activities.

Certainly, if good proposals come in, I would assume that they would have very high priority indeed within each of the programs. I think I can assure you of that.

Mr. LUNDINE. That is encouraging to learn.

I would finally like to ask just one detailed question. In a briefing that we have received on your budget, there is a sentence that says, "Furthermore, the applied psychology program has been zeroed out."

I do not mean to take something out of context, but along the same lines we were just talking about, that concerns me. Can you explain why you zero out applied psychology?

Dr. SLAUGHTER. I am not sure of the source of that briefing. But if it means that many activities which we used to refer to as "applied" have been eliminated in the Foundation, it is a recognition that we believe the arbitrary distinction between fundamental and applied research was self-defeating. In fact, programs of the type that Dr. Friedl just mentioned—some people might describe them as "applied"—would receive a favorable response within the Foundation.

I hope you are referring simply to the fact that we have eliminated parts of the Foundation which dealt only with applied projects.

Mr. LUNDINE. I guess I said that would be my last question, but let me ask one more nevertheless. I think I am going to be able to be here on Thursday, and I do not mean, as the others, to preempt, but we had a witness here a while ago who made an interesting observation to me.

He said that, with respect to this shortage of scientists and engineers, one small thing that he felt had been done in the past that ought to be encouraged or continued and was not, as I understood the testimony, was to really stimulate outstanding high school science teachers—reenergize them, or something.

His point was that a lot of young people are not going into science, mathematics, and engineering, and that they make their choices oftentimes in their high school years, and quite frequently based on being inspired by a great teacher in those areas or others.

He claimed that the support basically for, I think, summer programs to encourage outstanding science teachers had been cut off in recent years.

Without commenting on a specific program, do I understand from the answer to your previous question that you would be relatively favorable toward that kind of encouragement and feel that that deserved a fair amount of priority?

Dr. SLAUGHTER. As I said, the No. 1 problem is teaching. The best way to energize high school teachers is to pay them a decent salary. We are not doing that throughout the country.

Mr. LUNDINE. You know, I was just thinking about that as I was listening to your answer to the previous question. Maybe what we have got to get into is having some kind of science contest or something. They can pay their basketball coach extra.

You know why there are not so many physics teachers. They can make more money doing something else. An English teacher probably cannot, if you get right down to it.

From the standpoint of the school board, how are they going to pay them so much more? Maybe we have got to figure out gimmicks as ways around that.

Dr. **Slaughter.** No, we simply need to replace the rhetoric that some people use in education and replace it with action by local school districts to value education. We simply do not value it enough.

Mr. **Lundine.** Do you think just simply increasing teachers' salaries——

Dr. **Slaughter.** No, not that alone. The National Science Foundation had an effective program 20 years ago in high school teaching: summer institutes. They were exceedingly valuable. Those kinds of things need to be explored again.

Mr. **Lundine.** Maybe we could even get some private sector support for that. I would suggest to you that maybe your leadership is needed in that area.

Dr. **Slaughter.** We respond favorably to that charge. I hope you will be here on Thursday, Mr. Lundine, because we hope to identify such a program.

Mr. **Lundine.** Thank you. Thank you, Mr. Chairman.

Mr. **Walgren.** Thank you, Mr. Lundine.

Mr. Weber?

Mr. **Weber.** Thank you, Mr. Chairman.

Dr. Slaughter, welcome. It is good to see you again.

Dr. **Slaughter.** Thank you.

Mr. **Weber.** I would like to start at least on a more philosophical level. I am sorry I missed your opening statement. Maybe you did address this.

I still have a question in my mind, I guess, after going through just a year of this now as a new member of the committee, on exactly what the administration really does see in terms of a long-term role for the National Science Foundation.

I supported, as you well know, the reductions the administration wanted in the budget for budgetary reasons, but I am particularly interested in getting a better understanding in terms now of what beyond the budgetary problems the administration believes is the proper role for the National Science Foundation.

In the hearings we held last year when the administration first brought up its proposed reductions, there were a lot of questions raised about whether or not the administration indeed was committed to the long-term existence of the Foundation itself.

I would like to have you respond to that and in any other way you can as to what kind of a long-term role in times of presumed economic recovery this administration might see for the Foundation.

Dr. **Slaughter.** I appreciate that question, Mr. Weber, and I am pleased that you ask it. I can answer it unequivocally. The administration states with clarity that it believes the National Science Foundation's responsibilities for support of research are clear and must be continued.

There is a great deal of talk about the role of State governments and the private sector in support of some activities, but there is no question in the minds of the executive agency and the President with whom we deal—the Office of Science and Technology Policy and the Office of Management and Budget—that the Federal Government has a predominant responsibility in support of basic research. The administration intends to support that position.

There certainly are differing views concerning the relative importance of disciplines within that responsibility, understandably so, and the issue we will be discussing more on Thursday, the Foundation's responsibility in science and engineering education, is not so clear. But in support of research, the administration's long-term intent is to support the Federal role.

Mr. **Weber**. I appreciate that very much. I think that is the case.

What about in the area that we are talking about today, behavioral, biological, and social sciences? There is an increase in that budget, but it is an increase that is less than the projected inflation rate, coming on top of the fact that that was the area that was subjected to the most substantial reductions the last time around.

I do not want to imply anything or demean anyone's motives, but are you convinced that the administration, as they are committed to the existence of the Foundation, is committed also to the continued existence of that directorate?

Dr. **Slaughter**. Yes, I think the administration is committed to continuing the directorate's existence. There is a recognition that the cuts were too severe, but that a complete recovery within a year or two was asking more than the administration could respond to.

Mr. **Weber**. The reason I ask the question is that a lot of us who would like to pursue the administration's basic budgetary objectives and be supportive in that role, nonetheless, as you are aware, have some difficulties with the priorities that are expressed in the budget.

From time to time we think about areas where we think the Foundation could do some good, such as the area we will be discussing on Thursday, and are tempted to say, instead of dribbling the money into this directorate or that directorate when the long-term goal may be to get rid of it anyway, let us just move all of that money into something else and try to make a reasonable impact there.

You can assure us that you would not like to see that happen?

Dr. **Slaughter**. No, I would not like to see that happen, and the administration would not like to see that happen.

Mr. **Weber**. OK. Again addressing the Biological, Behavioral, and Social Science Directorate, in terms of the defense of that budget and the argument for more funding for that directorate that comes from outside the administration particularly, there are two major areas that are usually cited, and those are productivity and economics. Yet, as I look through the background information that staff has provided for us, it does not look to me like there is a lot of activity going on that does directly address those two problems which are cited most often to me as reasons why we should increase funding for that directorate.

What exactly is the Foundation doing in terms of productivity in economics, what have they accomplished, what is going on right now, and what does the budget that you are presenting to us envision in that area?

Dr. **Slaughter**. Some items that might be identified as economics are contained in the social and economic sciences budget. The Foundation also is supporting some extramural studies in the Policy and Research Analysis Division.

Mr. **Weber**. What do those studies get into?

Dr. **Slaughter**. They are examining the contribution of investments in research and development to productivity and to innovation in the Nation. The studies have looked at the correlation between investments at higher fractions of the gross national product with productivity ratios in this country, comparing them with other countries, trying to identify the differences that lead to the sometimes marked differences in performance.

Mr. **Weber**. Is there anything going on, on the impact of the deficit?

Dr. **Slaughter**. I am sure economists are examining that problem. A Nobel Prize in economics resulted from some of the research support provided by the Foundation in that area.

Mr. **Weber**. What about in the productivity area, are there studies going on that we can look to someday provide definite help to industry in terms of improving productivity?

Dr. **Slaughter**. I believe so. Again, we are examining the question of productivity, in both the STIA directorate and to some extent in the engineering directorate. We are looking for contributions and improvements in manufacturing and in productivity that may emerge from infusion of techniques like robotics. Such techniques have resulted from studies supported by the Foundation to examine ways in which productivity might be increased.

Mr. **Weber**. Within that area, I have one more specific question. I notice that there is a study under the environmental biology area to deal with acid rain. That is a great concern in my State. Is there still any work going on in that area?

Dr. **Slaughter**. Yes.

Mr. **Weber**. What are you hoping to achieve in that area? What are you focusing on in the area of acid rain?

Dr. **Slaughter**. We have an environmental biology program and a large program in the Division of Atmospheric Sciences, looking at all the issues involving atmospheric chemistry, trying to understand more about the atmospheric processes that lead to the maintenance of a high incidence of the chemical compounds and to acid rain. The understanding emerging from the investments in research are doing a great deal to improve both the knowledge of how acid rain forms and of ways in which it might be abated.

Mr. **Weber**. How is that program specifically going to be developed in the next couple of years given the budget requests of the administration?

Dr. **Slaughter**. It will be continued. Our support in atmospheric chemistry remains strong. At some point, however, the demonstration projects and the implementation studies would most likely be a responsibility of an agency such as NOAA, rather than of the National Science Foundation.

Mr. **Weber**. Shifting ground just a little bit—and I understand that this is going to be our topic on Thursday—I am not quite clear on the discussion you had with Mr. Gregg a few minutes ago in the science and engineering education area. As I understand it, and I apologize for not getting all of this, did you say there is a commission that is studying currently how State and local governments can better respond to some of these needs? Would you explain a little bit more what exactly that means?

Dr. SLAUGHTER. We have received approval from the National Science Board for the establishment of the Commission on Precollege Education in Mathematics, Science, and Technology. That Commission is not yet in place. We anticipate it will be in place in April. It will not be a commission to study anything; it will be a commission to develop an action plan which would show an appropriate role for an agency such as the National Science Foundation and other Federal agencies attempting to support State and local governmental efforts toward improved mathematics and science education in the secondary schools.

Mr. WEBER. I understand from your statements that the administration's philosophy is one that these educational activities by and large should be assumed by State and local government.

Dr. SLAUGHTER. Yes.

Mr. WEBER. Without arguing that for a minute, because I generally would accept that philosophy, does the administration to your knowledge believe that now today—I am thinking primarily in terms of our national defense needs—there is a substantial need for improvement in that area regardless of the level of government that assumes that responsibility?

Dr. SLAUGHTER. Yes, it does.

Mr. WEBER. Just looking at the economic situation in my State which has a high technology base and a substantial institute of technology at our University of Minnesota, we cannot possibly assume that State and local governments could assume the responsibility. We possibly could in a few years if we get the farm economy picked up and a few things like that, but given the administration's strategic emphasis, is it not really counter to those ends to see this kind of reduction in science and engineering education at this particular time, even if you accept the general administration's philosophy that in rosier economic times that ought to be a State and local responsibility?

Dr. SLAUGHTER. It would be a serious mistake if there were not a strategy being formulated to put in place a more effective program to address the specific issues you identified. We intend to have in place that strategy and that implementation to address these issues. We are receiving support thus far from both the Office of Science and Technology Policy and the OMB for going ahead and doing so.

Mr. WEBER. We will not be able to discuss that comprehensively on Thursday, I take it.

Dr. SLAUGHTER. We will describe the ground rules and the strategy we are fostering.

Mr. WEBER. I have no more questions. Thank you very much.

Mr. LUNDINE [acting chairman]. Thank you very much. We appreciate your testimony. If we have left out any questions, we will ask them on Thursday.

Dr. SLAUGHTER. Thank you.

Mr. LUNDINE. I am now going to call a panel, Dr. William D. Carey, executive officer of the American Association for the Advancement of Science and Dr. Thomas F. Malone, foreign secretary of the National Academy of Sciences to discuss the international aspects of this Foundation project. I will apologize in advance for a little scheduling problem we have. We would like to ask you to proceed. I may have to interrupt your testimony, however, because of time emergencies of another witness.

Mr. LUNDINE. Dr. Carey, do you want to proceed please?

[The biographical sketch of Dr. Carey follows:]

WILLIAM D. CAREY

William D. Carey is Executive Officer of the American Association for the Advancement of Science and Publisher of Science and Science 82 Magazines. Carey came to the Association following six years at Arthur D. Little, Inc., where he was Vice President in charge of the public affairs work of the company. Prior to joining Arthur D. Little, Inc., Mr. Carey was Assistant Director of the U.S. Bureau of the Budget, Executive Office of the President. He was graduated from Columbia University with a Phi Beta Kappa in 1940, received the M.A. in public law and government in 1941 from Columbia, and the M.P.A. in public administration from Harvard in 1942 while a Littauer Fellow.

During his service in the Bureau of the Budget, he headed variously the Atomic Energy Group, the Commerce-Transportation Section, the Labor and Welfare Programs Division, and the Human Resources Programs Division. He was named Executive Assistant to the Director in 1958, and a year later became Executive Assistant Director, the chief career officer of the Bureau. He was in charge of Presidential transition activities in the Bureau during the Eisenhower-Kennedy transition, and in 1966 he was appointed statutory Assistant Director. Since his departure from the government, he has been appointed by the President to the White House Conference on Food, Nutrition and Health, and to the National Advisory Committee on Oceans and the Atmosphere. He was a member of the Science and Technology panel of the President's Science Advisory Committee. He was appointed by the Secretary of Commerce, and served as a member of the Commerce Technical Advisory Board.

He is chairman of the U.S. side of the bilateral group in science policy of the U.S./U.S.S.R. Joint Commission on Scientific and Technological Cooperation. He served as Chairman of the Statutory Visiting Committee of the National Bureau of Standards, and the Brookings Institution's Advisory Committee on Government Programs. Mr. Carey was a member of the U.S. Steering Committee for the United Nations Conference on Science and Technology for Development and was a member of the U.S. delegation to the Conference. Mr. Carey is a member of the Board of Trustees of the MITRE Corporation and of the Russell Sage Foundation, and he was on the Board of Governors of the Center for Creative Leadership. He was Vice Chairman of the Bio-Energy Council.

Mr. Carey received the Career Service Award of the National Civil Service League in 1958, the Exceptional Service Award of the Director of the Budget Bureau in 1960, the Rockefeller Public Service Award in 1964, and the Edward F. Bartelt Award of the American Cancer Society in 1969.

Mr. Carey is a member of the National Academy of Public Administration, the American Political Science Association, and the American Society for Public Administration. He is a trustee of the Inter-University Program of Case Studies in Public Administration. He is a member of the Institute of Medicine of the National Academy of Sciences.

Mr. Carey served as a member of the National Science Foundation/Association of American Universities Advisory Committee for the "Study of the Future Research Role of Universities," and as a member of the Advisory Board of the Carnegie-Mellon Institute of Research. He has lectured on national policy-making as a professor at the Salzburg Seminar in American Studies. He was a member of the U.S. delegation to O.E.C.D. for the Review of U.S. Science Policy. He was a U.S. participant in the Ditchley Conference on non-profit organizations in 1969. He was a consultant to O.E.C.D. in 1969 on problems of resource allocation for scientific research and development. He participated in 1970 at a multinational conference in Ankara at the request of the Scientific and Technical Research Council of Turkey.

Mr. Carey was a member of the AAAS delegation to the People's Republic of China in November 1978.

STATEMENTS OF DR. WILLIAM D. CAREY, EXECUTIVE OFFICER, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE; DR. THOMAS F. MALONE, FOREIGN SECRETARY, NATIONAL ACADEMY OF SCIENCES, ACCOMPANIED BY DR. STANFORD PENNER, NATIONAL ACADEMY OF SCIENCES

Dr. Carey. Thank you, Mr. Chairman. It has been an interesting afternoon, Mr. Chairman and members of the subcommittee.

The statements and testimony that we have heard from Dr. Slaughter do confirm the support of the administration, the White House, and OMB for a strong program in the National Science Foundation. This is reassuring.

My own sense of the Foundation's budget on its present position is that it is a stronger and more affirmative budget than we saw a year ago. The commitment in the budget as I see it is toward some sustained policy intentions of supporting mainstream scientific research. We have discussed a number of points this afternoon in some of those areas.

There are some other parts of the National Science Foundation budget that I am less affirmative about. It is a mixed situation. It is frankly quite tragic to have to stand by while the statutory charge of the Foundation to advance science education is repealed administratively.

It is also disheartening to see the Foundation in effect closing up most of what it has been doing in the field of public understanding of science. In a world as tense and edgy as ours has become, there is little satisfaction from where I sit in a 15-percent cutback in international scientific program support because when you take the available $9 million that I see in the Science Foundation budget and spread it over the 30 countries that are involved, nearly half of it earmarked for Europe, there is not a great deal that I can say about it as to its likely efficacy.

The zero that shows in the Science Foundation budget for explicit travel to international scientific meetings is difficult to understand, although the answers appear to be that this is going to be provided for now out of research budgets. In other words, it will compete.

What bothers me is that with one hand we sign bilateral cooperative agreements and send delegations abroad to testify to our enthusiasm for scientific intercourse and interaction, and with the other hand we make it very tough for some of our scientists to get from here to there and to participate in the interactive processes of science that are mutually informative and which build the connections between scientific communities from country to country. It is not as though NSF had been running a travel bureau supporting scientific junkets and jetsetters. On the contrary, the support has been impartial and very selective and it has helped younger people to get into the picture. I think we are being shortsighted, and our failure to hold our own in international scientific exchanges will cause us eventually to lose influence in the forums of world class science. I see nothing to rejoice about there.

What I would like to do in the next few minutes, Mr. Chairman and members of the committee, is to talk to a different and more worrysome aspect of the Government's relationship with science. It is not an aspect that directly bears on the budget of the Science Foundation but it is part of the atmosphere and an aspect of our international posture.

It is not news to you that from various quarters in the executive branch there are complaints about the transfer of U.S. technology and scientific findings that are said to enhance the military capabilities of our adversaries—in this case the Soviets.

Demands are coming from Defense and from the intelligence community and from the State Department and elsewhere that scientists check in first with the Government before undertaking research or publishing, or face compulsion by the Congress to do that.

To my knowledge, with the exception of fission and fusion research related to weapons, there is not a peacetime precedent for generalized prior restraint on open and unclassified scientific research.

I am deeply concerned that even without congressional action we will see progressively tighter Government controls imposed on scientific communication both domestically and internationally through the export control and the executive order routes.

I think the consequences would be to suffocate the best science through intimidation, redtape, and uncertainty and deny the United States the payoffs that result from high quality interactive research. I do not see how this would do anything but damage our national security interests and impair exchanges with the countries of the free world.

A few weeks ago the journal we publish down at AAAS ran an account describing pending Presidential Executive order on national security information which is before the Congress now for comment. The thrust of the order reinforces the powers of the executive agencies to classify information.

As things now stand under existing policies, classification of basic research not clearly related to national security is forbidden. The new Executive order would remove that prohibition. In the current policy there is a balancing test specifying that if the need to protect certain information is outweighed by the public's interest in its disclosure, the material should not be classified. This balancing test is thrown out in the Executive order that is pending.

The current rules also say that if there is a reasonable doubt about whether to classify information, it should not be classified. The new order says that if there is a reasonable doubt, you classify it.

Under previous Executive orders there is a mandatory review of classified material after 6 years, and the pending order eliminates that.

I do not question, obviously, the President's authority to change the rules and to stiffen the classification powers of the agencies. But I certainly do question the wisdom of unleashing such open ended discretionary powers to classify. We have been there before and we know that the incentives work toward overclassification.

There is a place for classification in our security system but these are powers to be exercised only when there are grave reasons to exercise them and under diligent safeguards. I do not understand the absence of checks and balances in the proposed Executive order. I do not understand why all basic research not related to national security must be exposed to discretionary classification. I do not understand why the reasonable doubt provision has to be turned around and tilted toward classification.

If this order is signed and issued in its present form in a growing climate of hyperanxiety about what the Wall Street Journal calls high-tech burglary, much of the normal discourse of science will be silenced. I think that if we then doubled the Federal dollars for basic research, it would not make up for our losses.

I have expressed my opinions about prior restraint and censorship and overzealous classification in other places. I will not overdo it here, but I want to make it clear that I know of no American scientist who would disagree with the need to protect truly touchy knowledge from getting into the hands of hostile parties.

As it happens, my position coincides with that of Dr. Edward Teller who testified a year ago before the House Armed Services Committee. He said—and I am quoting—"If you would be inclined to tighten security I'd recommend against it." He also said, "On the contrary, I recommend loosening security because by doing so you can accelerate technologies that really count." And what he says and what I say is that it is better to rely on security by achievement than on security by concealment.

There is a sentiment in the scientific community for some arrangement to balance the conflicting goals of protecting security and maintaining scientific freedom. It is not going to be easy to find that balancing solution as long as the national security people cannot surface the hard evidence to make their case compelling. Also, it will not be easy if the Government unilaterally proceeds to change the rules of the road regarding classification, particularly of basic and open scientific research.

Instead of shouting at each other across the two sides of the river, it will be better if we can get down to talking and trying to understand where we are coming from and what we stand to gain or to lose. Belated as it is, I welcome the Defense Science Board's initiative in setting up a forum with some university presidents. It is a small step but it is a first step. Thank you, Mr. Chairman.

[The prepared statement of Dr. Carey follows:]

Testimony of

William D. Carey
Executive Officer
American Association for the Advancement of Science

Subcommittee on Science, Research and Technology
Hearings on the National Science Foundation

February 23, 1982

Mr. Chairman and Members of the Subcommittee:

Let me begin by remarking that the President's 1983 budget proposals for the National Science Foundation are reassuring and indicative of policy intentions to continue the government's postwar support of mainstream basic scientific research. If we take into account the provisions of the budget as a whole, including the defense sector, we have a proposed increase of about 10 percent for basic research, and though inflation will absorb most of the increase the total result must be viewed as a plus in these times. The final outcomes are by no means guaranteed, of course, and it will take a great deal of Congressional effort to hold to the increases as the budget moves through the legislative cycle.

There are some aspects of the NSF's 1983 budget that I cannot be so complimentary about. It is tragic to have to stand by while the statutory mission to advance science education is administratively repealed. It is disheartening to see the Foundation quitting its efforts on behalf of public understanding of science and settling for a steeply-reduced allowance in the area of ethics and values in science. And in a world as tense and edgy as ours has become, there is no satisfaction in a 15 percent cutback in the Foundation's international scientific programs. When you spread $9 million over the 30 countries that are involved, with nearly half earmarked for Europe and nothing provided for participation in the International Institute of Applied Systems Analysis in which some 17 countries have been represented, there is not a great deal that you can say for its likely efficacy.

When I see a zero in the NSF budget for travel to international scientific meetings I cannot understand it. With one hand we sign bilateral cooperative agreements and send delegations abroad to testify to our enthusiasm for scientific exchanges, while with the other hand we make it impossible for our scientists to participate in the interactive processes of science that are mutually informative and which build the connections between scientific communities. It isn't as though NSF had been running a travel agency for scientific junkets and jet-setters. To the contrary, partial support, and highly-selective partial support at that, has been the norm. Besides, NSF managed its $800,000 travel program in a way that provided access to younger, promising scientists. I believe that we are being shortsighted and that our failure to hold our own in international scientific exchange will cause us to lose influence in the forums of world-class science.

I would like to devote the rest of my time to a different and more worrisome aspect of government's relationship with science: an aspect that also bears on our international posture. It will not come to you as news that from various quarters in the Executive Branch there are growing complaints about the transfer of U.S. technology and scientific findings that enhance the military capabilities of our adversaries, in this case the Soviets. Demands are being made that scientists check in with government before undertaking or publishing research, or face compulsion by the Congress to do so. To my knowledge, with the exception of fission and fusion research related to weapons, there is no peacetime precedent for generalized prior restraint on open and unclassified scientific research. I am very deeply concerned that, even without Congressional action, we will see progressively tighter government controls imposed on scientific communication both domestically and internationally via the export control and executive order routes. The consequences, in my view, would be to suffocate the best science through intimidation, red tape, and uncertainty and deny the United States the payoffs that result from high-quality, interactive research. I cannot see how this would do anything but damage our national security interests and impair scientific exchanges with the countries of the free world.

A few weeks ago the journal of the AAAS, Science, published an account describing the pending Presidential Executive Order on National Security Information which, as I understand it, is before certain Congressional Committees for comment. The thrust of the pending order is to reinforce the powers of the Executive agencies to classify information. At the present time, under existing policies, classification of "basic scientific research information not clearly related to national security" is prohibited. The new Executive Order removes this prohibition. Under current policy, there is a balancing test specifying that if the need to protect certain information is outweighed by the public's interest in its disclosure, the material should not be classified. This balancing test is thrown out in the now-pending Executive Order. The current rules also say that if there is a reasonable doubt about whether to classify information, it should not be classified. The new Order says that when there is a reasonable doubt, classify. Under prior Executive Orders, there is a mandatory review of classified material after 6 years. The pending order eliminates this time limit.

I do not question the President's authority to change the rules and stiffen the agencies' classification powers, but I vigorously question the need and wisdom of unleashing such open-ended discretionary powers. We have been here before and we know that all the incentives work towards over-classifying. I think that there is a place for classification in our security interests but I also believe strongly that these are powers to be exercised only when there are grave reasons to do so, and under diligent safeguards. I do not understand the absence of checks and balances in the proposed classification policy. I do not understand why all basic research not clearly related to national security must be exposed to discretionary security classifications. I do not understand why the "reasonable doubt" provision must be tilted towards classification. If this Executive Order is, in fact, signed and issued in its present version, in a growing climate of hyperanxiety over what the Wall Street Journal calls "Hi-Tech Burglary," much of the normal discourse of science will be silenced and progress arrested. If we then doubled the Federal dollars for basic research, I do not think it would make up our losses.

I have expressed my opinions about prior restraint, censorship, and overzealous classification in other places and I will not quote myself here today. I want to make it clear that I know of no American scientists who disagree with the need to protect truly touchy knowledge from getting into the hands of hostile parties. And my position, as it happens, coincides with that of Dr. Edward Teller who, testifying last year before the House Armed Services Committe, said "If you would be inclined to tighten security, I would recommend against it. On the contrary, I recommend loosening security... because by doing so, you can accelerate technology in ways that really count."

What he said, and what I say, is that it is more profitable to rely on security by achievement than on security by concealment.

I sense a sentiment in the scientific community for some arrangement that would "balance" the conflicting goals of protecting security and maintaining scientific freedom. It will not be easy to find that balancing solution as long as the national security people cannot surface the hard evidence to make their case compelling. Nor will it be easy if the government unilaterally changes the rules of the road regarding classification. But instead of shouting at each other across the two sides of the river, it will be better if we can get down to talking and trying to understand where we are coming from and what is to be gained or lost. Belated as it is, I welcome the Defense Science Board's initiative in setting up a forum with unversity presidents. It is a small step, but a first step.

Thank you, Mr. Chairman.

Mr. **Lundine**. Dr. Malone, I think we would like you to present your testimony please.

Dr. **Malone**. Thank you, Mr. Chairman. For better or for worse I am old enough to remember vividly Vannevar Bush's book: "Science—The Endless Frontier," and the emphasis it placed upon the role of the National Science Foundation in international science and technology. I must say I grieve to see that eroded.

With your permission, Mr. Chairman, I would like to address a point that Congressman Brown raised—IIASA, which is an integral part of our international apparatus and one that is under active discussion at the moment. I have asked Prof. Stanford Penner, who is chairman of our academy's advisory committee, to be with me to answer questions that you might have about the specifics of the program.

I think it is timely that we look at this problem. Our academy is midway in a scrutiny of IIASA. Our commission on international relations which I chair has given it a detailed study. We will be reporting to the council on Saturday evening and the council will then come forth with an official academy position which I will be happy to forward to you at that time.

Mr. **Lundine**. Thank you. I wonder if I could ask you to suspend your testimony for a moment. I apologize, but at this point when you are just getting into the substance of it, I think it may be better than to wait. I appreciate your courtesy. We will then address both witnesses as a panel.

I would like to ask Gov. James B. Hunt, Jr., of North Carolina to come up to the witness table please. Governor Hunt, welcome.

Thank you, gentlemen, I appreciate your understanding. The Governor is under quite a tight schedule. It seems there are a few issues outstanding between the Federal Government and some

State governments these days. I guess that keeps Governors pretty busy. Governor Hunt, we welcome you to the science and technology hearings on the National Science Foundation budget, particularly to talk about the inner governmental and public service science and technology aspects, what we have under our jurisdiction. I extend a personal welcome. I feel very close to the State of North Carolina, having gone to college there and followed your career closely. You are certainly an outstanding leader, not only in your State but among the Governors of the United States. We are delighted to have you with us.

STATEMENT OF HON. JAMES B. HUNT, JR., GOVERNOR OF THE STATE OF NORTH CAROLINA

Mr. HUNT. Thank you very much, Mr. Chairman. I am very pleased to have the opportunity to testify at this hearing. I want to say to you and members of this committee, and the staff of this committee, that I appreciate your leadership in this field.

I am pleased to have an opportunity to testify at this hearing. The future of science and technology in this Nation and of the National Science Foundation in particular is of great importance to our country and certainly to my State of North Carolina.

Each member of this committee is aware that our Nation is confronted with severe economic problems. I believe that one of the major causes of our difficulties—in terms of productivity, international competitiveness, and so on, our failure to translate adequately the knowledge gained through research into products and services essential to our economic growth.

The United States has provided, and I believe that we must continue to provide, the fundamental scientific knowledge essential to sweeping technological changes. But Japan, as an example of a growing number of nations, is exceeding our ability to transform results of our research into superior products.

In my judgment, the National Science Foundation should be concerned with the entire process of research and development. I believe the record clearly demonstrates that the National Science Board, the Foundation itself, OMB, and the Office of Science and Technology Policy have been preoccupied with the basic research aspects of the process and have ignored or downplayed the rest. The National Science Foundation sought, in its latest reorganization, to overcome the shortcomings of which I speak.

But Mr. Chairman, we are still far behind Japan and perhaps a few other nations in effectively using the results of research for the benefit of our people. Thus, as a nation we must pursue the fundamental forms of scientific exploration and develop the necessary institutional arrangements, private sector financial support, and other means essential to effective use of scientific research results.

I do not believe that it is feasible for the Federal Government to implement directly all the measures required to insure effective use of research results. We should not be after that. A partnership of Government, academia, and industry is necessary and State and local governments must play a key role in this partnership, far more than has been the case in the past.

There is much, however, that agencies of the Federal Government level can do. They should and must maintain a favorable economic environment by controlling inflation and insuring adequate flows of capital at reasonable interest rates.

Second, the Federal Government should devise incentives designed to encourage investment in research and development.

Third, it should support basic research which is relevant to all States and assist groups of States in pursuing common research and development interests.

Now, we have concluded in North Carolina that State government should help support institutions, agencies, and firms in making sure that our research capacity is used effectively. The unit in our State that helps plan our strategy is the North Carolina Board of Science and Technology, which the Governor chairs. Several departments and agencies of State government assist in that whole process, including our department of commerce.

In addition, we have established the North Carolina School of Science and Mathematics, the only residential high school for exceedingly bright youngsters in math and science in this country. We are taking deliberate steps to improve the quality of math and science education throughout our public school system and we are determined to radically change and upgrade it.

To put us on the cutting edge of two important fields of technological change, we have established the North Carolina Bio-Technology Center and the Microelectronics Center of North Carolina. Our legislature appropriated $24.4 million this year for the microelectronics center.

We have created a waste management board and enacted legislation to insure that we are properly managing toxic, hazardous, and low-level radioactive waste. Many of our science faculty members, several of which are recipients of research funds from NSF, have been involved with this.

We have been able to move faster than many States, but even so, the support of the National Science Foundation through its States' science, engineering, and technology program has been of invaluable assistance to us in recent years. Indeed, I would say to you that many of the initiatives that we have taken, some of which are perhaps unique in the country at the State level, simply could not have come about at the same rate without the assistance we have received through this program.

Unfortunately that program is being cut out of the NSF budget in the current fiscal year. The SSET program is small but of critical importance to States and it should be restored and strengthened. It can become a strong influence in causing State governments to fulfill their roles in making technological innovation effective.

Somewhere in the Federal Government it is absolutely essential that leadership be exercised in fostering the type of activity such as is taking place in North Carolina and in a few other States. Mr. Chairman, I would like to conclude by suggesting that the leadership responsibilities I envision for the Federal Government could be exercised to a significant degree by the National Science Board, the National Science Foundation, the President's Science Adviser, and his associated Office of Science and Technology Policy. To do so, however, will require a good deal of rethinking on the part of each of those components as to their collective role in fostering action by State and local governments and the private sector, such as is beginning to occur in North Carolina.

We can no longer assume that research utilization will take place automatically by some trickle-down theory. The proposed NSF budget clearly falls short of fostering the kind of activity that must take place at the national level if we are to do a better job of translating research into better products and services.

If NSF is not going to be given the means to carry out this function, I think that Congress should give serious consideration to Representative George Brown's proposal for establishing a national technology foundation. But before you choose the technology foundation path, let me suggest that Congress and NSF can easily take a step together and soon. It would be consistent with my emphasis upon technological innovation, it would not require additional appropriations, and it would be consistent with the Reagan administration policies to stimulate innovative industrial growth.

I have reference here to H.R. 4326, the proposed Small Business Innovation Development Act of 1981. I would urge that that bill be passed without exempting any agency, although I suggest that the House proposal be brought into line with the bill passed by the Senate and supported by the administration. Several additional steps will be needed also to insure that more effective programs are established.

I recommend further that to save duplicative administrative expense among effective agencies, funds available under this legislation be consolidated and administered by the existing unit of NSF that is now managing the present NSF program. Such action would significantly enhance forms of technological innovation of which I speak. It would enable NSF to exercise leadership in forging the partnership relations with industry, academia, and other Federal agencies and State and local governments, the type of leadership that I recommend. If that leadership were pursued vigorously and effectively by NSF, it might eliminate the need for the National Technology Foundation that Congressman Brown has proposed.

I am aware of objections from some of our universities to this set-aside provision. This program, however, has the potential of drawing in, in my opinion, significant additional industrial support for research and development in this short run. In the long run it has the potential of making the entire R. & D. pie bigger and thereby increasing funds for basic research funds far beyond the amount that is set aside.

Mr. Chairman, I appreciate this opportunity to appear before you. I will be glad to try to respond to questions and I want you to know that we in North Carolina are constantly prepared to be of any assistance to you here as you pursue this matter.

Mr. LUNDINE. Thank you very much. Governor Hunt, what do you see as the major role of NSF regarding your State's science and engineering programs?

Mr. HUNT. Mr. Chairman, I believe that NSF should be primarily involved in basic research, obviously, as I indicated earlier. That is important and crucial. Certainly the scientists in the universities and other places within our State need that kind of help. But I think it is also essential that we have the kind of broad-based approach that I have been talking about. I think it is essential, very essential, that NSF be vitally involved in science education and the serious reduction of that portion of the NSF program concerns me tremendously.

What I have been trying to say to you, and let me say it now in a shorter form, is this. We are not going to get the kinds of resources that we need in this whole area simply by Federal appropriation, certainly not today or in this immediate era. We have got to get State legislatures to understand and commit to it, just as I persuaded our legislature to provide $24 million this year, in a tight year, for a microelectronics center, and $12 million—though we are using a lot of that for capital needs—for a special school for science and mathematics.

We need to get local governments understanding this and putting some funds into it. We need to get private corporations joining in with memberships in some of these organizations. We need to get groups within the corporate sector, groups like farmers who just in my State had a "nickels for know-how" program, a nickel in every bag of seed and feed and fertilizer. They just voted to make it "two nickels for know-how" in light of inflation.

You see, we have got to do a good job of education and we have to do a good job of getting all of these other groups to participate with us. I think the National Science Foundation needs to have that kind of comprehensive broad-based leadership approach.

Mr. LUNDINE. And specifically in education, you have received benefits from some of the NSF programs?

Mr. HUNT. Absolutely. From the program of which I speak where we received help, we utilized those funds working through my office, the office of science and public policy adviser. We had one person with additional help that specifically assisted us in getting not only our microelectronic center developed and funded—and that brings in a number of universities, five within our State—with the public sector, but also helped us move ahead with our math and science high school and to get all of those things worked out.

The most recent thing, Mr. Chairman, is to develop the kind of approach we can take to radically upgrade the quality of math and science education throughout the public schools in our State. That is a job ahead for us. We have done a few things. There are many things left to do. We have identified a number of things that do not cost any additional money, a number of things that cost perhaps a few hundred thousand, other things that will cost several million.

But the people and the resources that we have had from those funds have enabled us to work on these things, find out what is possible, set that agenda, and start moving, enabling the Governor to have the kind of understanding and help he needs.

Governors are very busy. They can go a thousand ways. Very few of them have gotten involved in giving their personal leadership, using their budget, working with the universities, working with the public school people, with the corporate heads in this field.

Unless you have the kind of help I have had, you simply will not have the background and the resources to move ahead and take leadership. I have had it and we have been able to do it.

Mr. LUNDINE. Now, the current request for all NSF intergovernmental programs is $500,000. This compares to $5.5 million in fiscal 1981. As you know, this science for citizens program has gone from $2.1 million to zero and appropriate technology program has gone from $1 million to zero. Did I understand implicit in your testimony is that in those intergovernmental programs States are not going to be able to pick up that entire amount in your judgment, at least in 1 year? Can you give us any guidance on what you believe would be a fair level of funding, given that we have funded $5.5 million last year? Is there any guidance in that regard?

Mr. HUNT. Mr. Chairman, it is hard for me to be very specific about that. Let me say that I think the level at which NSF was being funded was not excessive by any means at all. I mean by this that NSF should take seriously the need to reach out now to become more comprehensive in the way it approaches things, to develop these private sector industry-related aspects and build support from them. That we must do. However, I think the funding level ought to be at least $5 million. This is one of the areas we ought to be increasing our efforts in, not decreasing. These would be the most shortsighted cuts in the world.

I want to say to you specifically, in terms of much of the industry in North Carolina, very directly and very soon the SSET type of support means jobs for my people. That is what it is going to mean for this country. That is the way we are going to compete and be dominant in the years ahead.

Mr. LUNDINE. Having asked you a very specific question, I want to conclude by asking you a very general one. North Carolina has been a leader in developing a partnership between universities and government and in putting together an industrial strategy particularly oriented to research and new technology. To some extent, I am aware that this is an effort that has been going on for 25 years or more under the leadership of you and your predecessors.

Other than the Small Business Innovation Act you testified about, and on behalf of Congressman Brown who was here earlier—I will also thank you for your endorsement of his technology foundation—do you have any advice for us in trying to develop a similar spirit of partnership between the national need for increased innovation and the private sector in the whole American context?

Mr. HUNT. Mr. Chairman, I think this has to be done by the top leadership in this country. We have made much of the progress in North Carolina, certainly in our research triangle with Duke, the University of North Carolina, and North Carolina State. Similar partnerships are developing in the Charlotte area with the great universities there and in the Greensboro-Winston-Salem-High Point area, because we have had leaders who have given it top priority.

Gov. Luther Hodges is an example, as well as Gov. Terry Sanford and other far-sighted Governors, who have thrown themselves into it. They have seen it as a responsibility of public leaders. They have done two things primarily.

They have helped our people understand why major investments in education—and similar to that, in research and development—are essential for a good economic future.

They have built those ties and relationships with private industry. Private industry, then, being more supportive of all the things we are trying to do, including education, is persuaded then to invest.

Then you have almost a sort of joint enterprise of government, industry, and academic. Frequently, I have sat down with the presidents of my universities—yes, Bill Friday, the head of the University of North Carolina, Terry Sanford, the head of Duke University, the heads of major corporations in our State and those outside of the State that were planning to come into the State with major kinds of facilities. We have talked together about what our needs are: What kind of engineering program do you need over here? How many more students do we need to be putting into different areas? What do we need to be doing about the public school system? What kinds of additional resources do we need to commit and what will they commit?

I think the President has got to give that leadership. I think the leaders of the Congress have got to do it and I think we are going to have to develop an overall strategy. I will not use the word plan because I know there is some onus attached to that word—although I spent a couple of years overseas with the Ford Foundation as an economic adviser and we developed 5-year plans. That has been done all over the world in many good countries. Let us call it a strategy.

This country has got to have a strategy for economic growth. That strategy will readily recognize that the communications area and the high-technology industries are the growth areas for the future. We have got to say that. We have got to say that that is our goal.

Japan says that. They will say that microelectronics is the rice of industry or whatever their terms are. And they get all of their people together. Let us go forward. This is where we are going to go. This is what we have to do. They are beating our pants off with it, Mr. Chairman. We have got to take leadership. Our public leaders have got to give it leadership.

Our academic people are ready to go; I have never found them reluctant one whit to come in and join us and to serve. They know that universities are to serve. Of course, I think our business and industry leaders would be prepared to join us.

I do not know exactly how to lay it out to you. We are doing it in our State. I think the President has got to give it leadership, however, and you should work with him. If he does not do it, I would suggest that the Congress try to give it leadership as congressional leaders.

Mr. LUNDINE. Thank you very much, Governor. You certainly have provided a context into which all of these National Science Foundation hearings can be better perceived. We appreciate your testimony.

Mr. HUNT. Thank you.

Mr. WALGREN. Mr. Chairman.

Mr. LUNDINE. Mr. Walgren is here.

Mr. WALGREN. I know you have a commitment, Governor. I will not keep you. I just wanted to ask you this. We can justify these programs in several ways and I understand the macrojustification and that we need to have economic growth in this country to do what we have to do. But in the intergovernmental area, is there a direct benefit to the taxpayer on the State and local level that has come out of these programs other than the overall economic growth that we might get through innovation and technological development?

Mr. HUNT. Congressman, I think there have been a number, and obviously you can get many examples. The Landsat project was certainly one of those in which, for all kinds of mapping purposes, we were able to utilize the maps made in some of the Federal programs by some of the satellites. We have worked through that program to make available scientific discoveries that came through our defense programs. We have also held daylong exhibitions in some States to involve private industry and local governments.

I would suggest to you that the working together, that partnership of the Federal Government and State government—and I served as cochair of ISETAP for awhile—and local governments in focusing on what we need to be doing, the strategies we need to use, and the sharing that we have had—all this has stimulated us to do the right things within our States in making proposals to our legislatures and at the county level.

So, there have been specific things, pieces of information we have gotten, and processes that have been developed that we have been able to utilize at different levels. But there is this coming together and working toward a strategy, becoming aware of what is possible, and having our awareness sharpened that I think has been one of the great benefits of ISETAP.

[The prepared statement of Governor Hunt follows:]

TESTIMONY BY GOVERNOR JAMES B. HUNT, JR.
BEFORE THE
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
FEBRUARY 23, 1982

Mr. Chairman:

I am pleased to have the opportunity to testify this afternoon at this important hearing. The future of the science and technology of this nation, and of the National Science Foundation in particular, are of great importance to the State of North Carolina. And, as exemplified by the meeting of the Task Force on Technological Innovation of the National Governors' Association held here in Washington two days ago, it is important to other states as well.

I am going to suggest in my testimony that some things remain undone that NSF and the Office of Science and Technology Policy might well do. Therefore, let me state at the outset that the Foundation is of indispensable importance to the United States. Its fundamental scientific explorations should be greatly strengthened; in no way should they be curtailed or diluted.

Each member of this committee is quite aware that our nation is currently confronted with economic problems of considerable severity and consequence. It is my strong conviction that one of the major causes of our difficulties is that we have failed to translate adequately the fundamental knowledge gained through research into products and services essential to our economic growth. Significant aspects of this research are funded, of course, by the National Science Foundation.

The United States has provided, and has the potential to continue to provide, the fundamental scientific knowledge essential to sweeping technological changes. But Japan, as an example of a growing number of nations, is exceeding our ability to transform results of our own basic research into superior products--products that are capturing many markets of the world, including markets in the U.S.

Scientists sometimes refer to the utilization of the results of basic research as "applied research." I find the term "applied" inadequate, and the distinction between basic and applied research both limited and misleading. We should be concerned instead with the entire process of research and development. It includes not only the most fundamental forms of scientific exploration, but also the collection of public and private sector activities required to transform research results into goods and services of benefit to society.

In my judgment, the National Science Foundation should be concerned with the entire process of research and development that I have described. Instead, I believe the record clearly demonstrates that the National Science Board, the Foundation itself, OMB and the Office of Science and Technology Policy (OSTP) have been preoccupied with the basic research aspects of the process, and ignored or downplayed the remainder. For example, if the NSF budget must be reduced, or proposed expansion curtailed, it is the hard-core of "basic" research that is retained. Cuts come in such fields as "intergovernmental science, science education, social science research" and other programs construed to be outside the mainstream of "basic" science.

The National Science Foundation sought, in its latest reorganization, to overcome the shortcomings of which I speak. The Engineering Directorate was created and assertions made that much more attention would be given to "applied" research. I applaud the creation of the Engineering Directorate and all these good intentions, but we are still far behind Japan and perhaps a few other nations in effectively using the results of research for the benefit of our people.

In recent remarks at the annual meeting of the American Association for the Advancement of Science, I used the term "technological innovation" to represent the process beyond, or in addition to, fundamental research pursuits--processes essential to effective utilization of research results. (I will leave a copy of this address with the committee.) To illustrate my intended meaning of this term, I quoted Don Price of Harvard University when he observed, based upon his survey of the World War II period:

> The most significant discovery or development for science and technology to come from the war effort was not the technical secrets that were involved in radar or the atomic bomb, it was the administrative system and set of operating policies that produced such technological feats.

In other words, the organizational innovations developed on a national scale during and following World War II were as important, if not more important, than the technical innovations of radar and atomic weaponry. But each is dependent upon the other. Thus, as a nation, we must pursue fundamental forms of scientific exploration, and develop the necessary institutional arrangements, private sector financial support, and other means essential to effective use of scientific research results.

There are two points I would like to make here today, Mr. Chairman, based upon this concept of technological innovation.

First, I do not believe that it is feasible for the federal government to implement directly all the measures required to ensure effective use of research results. A partnership of government, academia and industry is necessary, and state and local governments should play much more important roles in this partnership than in the past.

There is much, however, that agencies of the federal government can do. For example, they should (1) maintain a favorable economic environment by controlling inflation and ensuring adequate flows of capital at reasonable interest rates;

(2) devise additional tax and other incentives designed to encourage investment in research and development; (3) strongly support basic research relevant to all states (and this is particularly the role of the National Science Foundation); and (4) assist groups of states in combining together to pursue common research and development interests. Measures such as these comprise the role of the federal government in fostering a broad-based program of technological innovation across the country.

As for the state government role, my second point, we should remember several relevant conditions: (1) of the 184 Ph.D.-granting research universities of this nation, 119 are public institutions, most of which are supported by state governments; (2) elementary and secondary educational systems are the responsibility of state and local governments, and science and mathematics instruction at these levels need extensive and striking improvement; (3) industrial firms, farms, banks, wholesale and retail outlets, transportation systems and all other forms of economic activity exist and function within state boundaries and relate closely to state and local governments; and (4) people live within state and local government jurisdictions and must be included as an absolutely essential partner in technological innovation because the entire system must work in their interest.

Because of these conditions, we have concluded in North Carolina that state government should help support these institutions, agencies and firms in making sure that our research capacity is used effectively in dealing with problems and seizing opportunities in our state and elsewhere. The unit that helps plan our strategy is the North Carolina Board of Science and Technology. Several departments and agencies of state government assist in the process, including our Department of Commerce. We have established the North Carolina School of Science and Mathematics as a means of training and inspiring some of our brightest young people in these fields. This school is also part of our program to improve the quality of education in our elementary and secondary schools. To put us on the cutting edge of two important fields of technological change, we have established a Biotechnology Center and a Microelectronics Center, investing more than $24 million of state funds. We have created a Waste Management Board and associated legislation to ensure that we are properly managing toxic, hazardous and low-level radioactive waste.

Thanks to the foresight and good work of my predecessors and others, we have been able to move perhaps farther and faster than many states. Even so, the support of the National Science Foundation, through its State Science, Engineering and Technology (SSET) Program, has been of great assistance to us in recent years. Unfortunately, it is being cut out of the NSF budget in the current fiscal year.

This action by NSF, OMB and such others as have been responsible for cancelling the SSET Program, illustrates the point I am seeking to make and should be restored. The SSET Program is small but of critical importance to states. It can become a strong catalytic influence in causing state governments to fulfill their roles in making technological innovation effective. Somewhere in the federal government it is absolutely essential that leadership be exercised in fostering the type of activity such as is taking place in North Carolina, and in a few other states.

The term "intergovernmental science" has been used frequently to encompass the state and local government related programs of NSF. During my period of service as Vice Chairman of the Intergovernmental Science, Engineering and Technology Advisory Panel (ISETAP), which was chaired by Frank Press, under President Carter, I became quite familiar with activities of both state and local governments throughout the country in matters such as I am discussing today. Since that experience, I have come to believe that we must broaden the concept of intergovernmental science to include the research utilization responsibilities pertaining to economic development.

Now let me conclude by asserting that the leadership responsibilities I envision for the federal government could be exercised to a significant degree by the National Science Board, the National Science Foundation, the President's Science Advisor and his associated Office of Science and Technology Policy. To do so, however, will require much rethinking on the part of each as to their collective role in fostering action by state and local governments and the private sector, such as is beginning to occur in North Carolina. We can no longer assume that processes of research utilization, including all of the organizational requirements, will take place automatically by some trickle-down theory. In the press releases concerning the proposed budget of NSF, however, I do not perceive that this is the direction in which we are going.

If the budget, associated programs and the administrative organization of NSF, the Board and OSTP cannot be broadened and extended to include such functions now and continuing into the future, then we have no recourse but to follow a proposal such as Congressman George Brown has put foward, namely to establish a National Technology Foundation (H.R. 3749, 1981), modified to provide for stronger roles by state and local governments.

Before choosing the Technology Foundation path, however, I would like to suggest a step that Congress and NSF can easily take together, and soon, that would be consistent with my emphasis upon technological innovation, that would not require additional appropriations and that would be consistent with Reagan Administration policies designed to stimulate innovative industrial growth.

I have reference to HR 4326, the proposed "Small Business Innovation Development Act of 1981". I urge that this bill be passed without exempting any agency, although I suggest that the House proposal be brought into line with the bill passed by the Senate and supported by the Administration.

I recommend further that, to save duplicative administrative expense among affected agencies, the funds available under this legislation be consolidated and administered by the existing unit of NSF now managing the present NSF program.

Such action would significantly enhance forms of technological innovation of which I speak. It would enable NSF to exercise leadership in forging the partnership relations with industry, academia, other federal agencies and state and local governments--the type of leadership I recommend. If pursued vigorously and effectively by NSF, it might well eliminate the need for the National Technology Foundation.

I am aware of objections from some of our universities to the set-aside provisions. This program, however, has the potential of drawing in significant additional industrial support for research and development in the short run. In the long run, it has the potential of making the entire R & D pie bigger and thereby increasing funds for basic research far beyond the amount of the set aside.

ACADEMIA, INDUSTRY AND GOVERNMENT: THE ORGANIZATIONAL FRONTIER OF SCIENCE TODAY[1]

I. INTRODUCTION

Dr. Berendzen, members and guests of the American Association for the Advancement of Science. It is a distinct honor and privilege to appear before you tonight. The 134-year history of this organization is a record of outstanding leadership and achievement.

I am always stimulated, in particular, by the penetrating editorials of William Carey and Philip Abelson, as they appear in Science. I look forward also to what your President, Allan Bromley, will say as he speaks of the "other frontiers" of science later this week.

As a Governor, I feel very keenly the need to stimulate vigorous dialogue between scientists and engineers on the one hand and political and industrial leaders on the other. For I believe that we simply cannot achieve the goals we set for ourselves--in North Carolina and in this nation--without that dialogue.

Nearly twenty years ago James R. Killian, then chairman of MIT, addressed a conference of state governors held in Miami. He began as follows:

> Much has been spoken and written in the last decade and a half about science and government, and the discourse has dealt almost exclusively with the federal government.... At MIT, I occasionally give a graduate seminar on science and public policy, and I must admit that state governments are hardly mentioned, an omission marking similar seminars in other universities and most of the books published on the subject.

Dr. Killian goes on to say that the Governor's Conference he was addressing was a "start in re-dressing this neglect" of science in state governments.

Unfortunately, state governors have not made the progress expected twenty years ago. But neither has the federal government nor the private sector. The glaring fact is that, in the United States today, we are not realizing the full creative potential of science and technology. It is upon our failure to do so, and upon the steps we must take to realize this potential, that I concentrate my remarks tonight.

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[1] Address by the Honorable James B. Hunt, Jr., Governor of the State of North Carolina, at the Annual Meeting of the American Association for the Advancement of Science, Washington, D.C., January 4, 1982.

To me, the creative potential of science--that is, the potential benefit to society--is achieved through technological innovation. I believe, however that a serious crisis is now emerging in the U.S. because we have not mastered the processes of innovation, as have Japan and a few other nations.

II. THE EMERGING INNOVATION CRISIS

Before spelling out the nature and significance of this emerging crisis, let me describe what I mean by technological innovation.

Meaning and Importance of Innovation

I view technological innovation as consisting of two interrelated parts: technical and organizational innovation.

Technical innovation is developed through use of physics, chemistry, biology and other natural sciences, plus mathematics and engineering. Such knowledge makes it possible to produce new or better physical or biological products, or produce them more efficiently.

Organizational innovation is accomplished through the use of economics, political science, sociology and other social and behavioral sciences. The objective is to change the organization and operation of units of society. Organizational innovation can occur on a large scale, such as at the national level. Or it can be on a small scale, such as in an office or an industrial firm.

Now with these concepts in mind, let me call your attention to an observation made by Professor Don Price of Harvard University, as he surveyed the World War II period:

"The most significant discovery or development for science and technology to come from the war effort was not the technical secrets that were involved in radar or the atomic bomb;" he said, "it was the administrative system and set of operating policies that produced such technological feats."[1]

In other words, the organizational innovations developed on a national scale during and following World War II were as important, if not more important, than the technical innovations of radar and atomic weaponry. But each is dependent upon the other. We cannot reap the benefits of science without both.

I suggest also that proper study of technological innovation, as I have defined it, is as challenging as genetic engineering or cellular biology. Forms of scientific and engineering knowledge, like genetic codes, influence the behavior of components of society; and, like the cellular structures of higher organisms, the interactive behavior of these components give form and character to society.

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[1] See U.S. Congress, House Committee on Science and Astronautics, Subcommittee on Science, Research and Development, report entitled Toward a Science Policy for the United States (Washington, D.C., USGPO, 1970), p. 81.

The importance of technological innovation arises from the fact that no modern society can function as such today without making effective use of scientific knowledge. Our military strength, as Price has noted, depends upon it. But of greater significance to the emerging crisis today is the dependence of economic productivity upon our ability to innovate, both technically and organizationally. The problem, as I see it, is that we still have essentially the same organizational structure for science and technology that was designed in World War II and the Korean War.

Even establishment of the National Science Foundation in the early 50s was influenced by the war experience. And the burst of federal support for science that followed Sputnik in the late 50s was inspired more by national security concerns than by the altruistic potential of science for all humanity.

Federal expenditures now dominate all research and development in the U.S.--$42 billion out of a total of around $70 billion. Within the federal outlays, defense-related expenditures are by far the most dominant category--$24 billion out of $42 billion.[1] Thus, in several respects, it may be said that science and technology have ridden the coattails of defense and space since World War II.

The unique aspect of military and space research is that provision is made for technological innovation by actually producing and using weapons' systems, rockets, tanks, ships and guns. DOD and NASA organize to use the results of research in fulfilling these federal objectives. Whereas, for fundamental non-military research, little provision is made for effective utilization of results--the critical fault of our present system.

Evidence of the Emerging Crisis

A very great deal has been accomplished over the last 30-to-40 years by our prevailing structure of science and technology. We have won wars. We have more Nobel Laureates than any other nation. We have shared our technology through foreign assistance.

And for a time we were the marvel of the world with respect to scientific achievement and technological advancement. Now, however, certain deficiencies are becoming apparent. I will list just a few:

1. Economic productivity. Output per man-hour in the U.S. has leveled off in recent years; in some it has declined. A recession now prevails, inflation continues, and unemployment is rising. What is more, we are now deliberately seeking to control inflation by slowing down economic growth, rather than by measures designed to increase productivity.

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[1] Willis H. Shapley, Albert H. Teich and Gail J. Breslow, Research and Development, AAAS Report VI, (Washington: American Association for the Advancement of Science, 1981) pp. 17, 87.

Fundamental research accomplishments no longer percolate through our economy with sufficient rapidity and effectiveness to substantially increase productivity. Japan, for example, drawing heavily upon our own research, is exceeding our ability to transform such fundamental knowledge into useful products with worldwide market potential.

2. Education. U.S. education, especially at the elementary and secondary levels, is significantly less rigorous than that of several other nations at the present time. For example, five million students graduate from secondary institutes in the USSR each year having had two years of rigorous instruction in calculus. By comparison, of all our high school graduates each year, little more than 100,000 complete but one year of calculus.[1]

Our work force as a whole is not keeping pace with the needs of a highly technical society. Critical shortages exist, not only of well-trained engineers but of engineering faculty. Shortages are emerging in relation to other areas as well, such as biotechnology. Financial support for universities, the status of scientific equipment and research facilities, and the opportunities for young faculty--all these and other measures of the vitality of our academic institutions are discouraging, as you well know.[2]

3. Environmental Management. The latest New York Times/CBS News Poll reports that "a large majority of the American public supports continued strong protection of the environment even if it requires economic sacrifice." Clearly, we have the scientific capability to properly manage land, water, and air resources and to minimize the dangers associated with toxic, hazardous and low-level radioactive waste. But we have not yet devised the organizational means to generate and use such knowledge adequately and effectively.

Views of the American Public

The American public views the present situation much as I have outlined, according to the pollster, Louis Harris.[3] Americans want inflation curbed, government expenditures cut, economic productivity increased, our technological capability greatly enhanced, and America's standing in the world restored. They feel that government performance has been costly and often ineffective, that industry has concentrated upon minor short-run gains at the expense of major long-run breakthroughs, that the scientific capacity of our universities is ten years out of date, and that things should begin to turn around by the end of 1982 if the policies of the Reagan administration and American business are going to prove effective.

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[1] Izack Wirzup, University of Chicago, in a letter report to the National Science Foundation in 1979.

[2] Cf. Willis H. Shapley, Albert H. Teich, Gail J. Breslow and Charles B. Kidd, Research and Development, AAAS Report V, (Washington: American Association for the Advancement of Science, 1980) pp. 88-90.

[3] Louis Harris, The Crisis of '82, address presented at the Yale Political Union, Yale University, New Haven, Connecticut, September 10, 1981.

Harris concludes that reliance by the Reagan administration upon free market forces will not right the economy, that the private sector may not be up to the task, and that American patience will be stretched to the breaking point within a year. Resolution of the crisis of confidence will not be through reversion to New Deal economics. Instead, a redefinition of the role of government will be essential.

I concur with Harris' conclusion. A redefinition of the role of government is needed now, however, and will likely be even more in order in the months ahead.

III. INNOVATION AND THE ROLE OF GOVERNMENT

The emerging crisis presents a challenge to our ability to innovate comparable to that which we faced in World War II. The overriding question now, as then, is how to organize our remarkable scientific and engineering capability. Now it should be for peace; then it was for war.

The situation both then and now demonstrates the central importance of science and technology to this or any society. It follows, therefore, that those who devise the organizational means to resolve this emerging crisis--who successfully redefine the role of government in relation to academia, industry and the general public--will also reap the rewards of economic and political support inherent in the fundamental desires of Americans throughout this country. I fully anticipate that the American Association for the Advancement of Science, as exemplified by this audience, will be in the forefront of these endeavors.

Leadership and Style

In redefining the role of government in relation to research institutions, industry and the general public, I contend that the center of gravity for technological innovation must shift from the federal government to state governments. This will require greater differentiation between the role of the federal government and the roles of state and local governments. And the style of government at each level will need to be catalytic, fostering the creative spirit of technological innovation throughout society, and not just down from the top.

The Federal Role

Before outlining the state role, I should note that the federal government must play an important supportive role. Elements of support should include (1) maintaining a favorable economic environment by controlling inflation and ensuring adequate flows of capital at reasonable interest rates; (2) providing tax and other incentives designed to encourage investment in research and development; (3) strongly supporting basic research relevant to all states; and (4) assisting groups of states in combining together to pursue common research and development interests.

The point to be stressed is this: Measures such as these comprise the role of the federal government in fostering a broad-based program of technological innovation across this country. The federal role is not to "administer" innovation through the same style of leadership that is followed in devising a new weapons system or in putting a man on the moon.

The Role of State and Local Governments

Turning now to the state government role, much is spoken these days of a partnership of government, academia and industry. I believe that such a partnership is essential, and that the best way to organize it is through state government leadership.

Remember that, of the 184 research universities of this nation, 119 are public institutions, most of which are supported by state governments. Many of the remaining private institutions receive some form of state support. Virtually all university research is conducted by these 184 institutions, and they exist in every state. State governments are committed to higher education but, for the most part, they have not learned how to foster and utilize in a catalytic fashion the tremendous research capacity of our academic institutions. This must be remedied. Academia is where we train our scientists, engineers and technicians. It is where scientific exploration takes place that makes technological innovation possible.[1]

Remember also that elementary and secondary educational systems are the responsibility of state and local governments. Science and mathematics instruction at these levels of education needs extensive and striking improvement. Regardless of action by the federal government, significant improvements will be achieved only if state and local governments take the lead in doing so.

Remember too that industrial firms, farms, banks, wholesale and retail outlets, transportation systems, and all other forms of economic activity exist and function within state boundaries and relate closely to state and local governments. These units of government are the prime points of contact with respect to locational issues, labor relations, environmental management, provision of capital (both human and material), living conditions for employees, and other facets of economic activity that entail industry-government interaction.

And remember, in addition, that people live within state and local government jurisdictions. I include people as an absolutely essential partner in technological innovation because the entire system must work in their interest. We cannot regard people as simply another abstract factor of production called labor—a factor that is used and discarded at will, and for which the system has no overall responsibility. Our children, our youth, our workers of every type in their most productive years, and our senior citizens are all indispensable participants. People can relate to state and local governments easier than to a distant federal agency. Therefore, if state and local governments play a more significant role in technological change, that change is likely to be more responsive to the desires of people, particularly if the partnership reaches out to include them.

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[1] Data pertaining to universities is from Shapley, et al., Research and Development: AAAS Report V, pp. 83-90.

Examples of State Leadership

To illustrate how a state government can forge the partnership relations of which I speak, let me share some of the experience of North Carolina and a few other states.

First, certain state level organizational arrangements are essential. The North Carolina Board of Science and Technology is the unit that maps much of the strategy by which we are proceeding, building upon the work of our universities and the influence of our Research Triangle Park. As Governor, I chair this 15-member Board; the remaining members are scientists from our public and private research institutions and officials from state and local government.

I also have other groups that advise me and help develop the essential working relationships. One, for example, is a council of business leaders from across North Carolina. Our North Carolina Department of Commerce works closely with this group and other institutions, firms and individuals, within and outside North Carolina. As a consequence, new industrial investment in North Carolina has averaged approximately $2 billion per year for the past five years. Our unemployment rate is running about two percentage points below the national rate as the current recession unfolds.

Some twenty states now have organizational arrangements resembling that of North Carolina. Another ten are beginning to initiate such arrangements. The remaining twenty appear to be less active at present but are exploring possibilities.[1]

Next, in North Carolina we are investing in people, particularly young people. In our elementary and secondary schools, we have introduced competency testing, raised teacher pay and improved their training, reduced class size and taken other measures to improve education in general. Significant improvements in national test scores are one indication that these changes are having an effect.

In addition, we have established the North Carolina School of Science and Mathematics. This is a residential high school for students with very high aptitudes for science and mathematics. The purpose of the School is two-fold: (1) To train and inspire those students in residence to become future leaders of science, and (2) through outreach programs, to help upgrade science and mathematics instruction in all elementary and secondary schools of the state.

Now in its second year, 300 students are enrolled. No more than 900 will be in residence when it reaches full capacity, with about 15 percent from out-of-state. I should add that about an equal number of girls and boys are enrolled, that the distribution of students by race is proportionate to that in the state, and that students are drawn from small rural schools as well as from large city schools.

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[1] See State Activities to Encourage Technological Innovation, a report prepared for the National Governor's Association by the State of California, August, 1981. Also, a record of progress is maintained by the "State Science, Engineering and Technology Program," National Science Foundation, Washington.

It is too early to gauge effects, but in its first year with 150 students enrolled, this school had the second largest number of 1982 National Merit Scholarship semi-finalists of any school in the nation.

My last example consists of our Microelectronics Center and our Biotechnology Center. The Microelectronics Center is designed to enable six of our leading research institutions in North Carolina to have access to very sophisticated microelectronics research equipment on a sustained basis. This will make it possible for these institutions to remain on the frontier of research and education in this field. Such equipment is extremely expensive and becomes obsolete quickly. We established the Center in order that these institutions may share this equipment. Otherwise we could not afford to equip each at this level of sophistication.

Further growth of microelectronics firms, and of firms that use microelectronics products, is expected in North Carolina as a consequence of the availability of highly trained engineers and other professionals, plus the advantage of being near vigorous research activity.

Our North Carolina Biotechnology Center is beginning on a relatively small scale, but represents a long-run commitment to this field. We recognize that many financial, patent and other issues must be explored carefully as we develop closer working relations between industry and our research institutions and government.

Our intent is for North Carolina to become a national leader in biotechnology research and development. Our key research institutions, working closely with the Center and with our Department of Commerce, are planning major developments in research programs, faculty and facilities in order to achieve this goal.

Other states are beginning to take action in relation to fields of exploration such as microelectronics and biotechnology. California has initiated a program of financial support to research and development in microelectronics. The states of Minnesota and Michigan are taking significant action also. Florida is providing significant funding for biotechnology. There are many more examples. The important point is that the nature and extent of state government activity is increasing steadily.

You may ask whether state governments are able and willing to provide financial support to such activity. Let me assert emphatically that I believe that any legislature will provide strong support for research and development _if_ you demonstrate that the state will indeed benefit from the research. I do _not_ subscribe to the belief that total support for research and development is fixed, and that if we increase expenditures for technology we take it away from basic research.

I make this assertion in spite of the fact that total appropriations by all 50 states for directed research is now less than $500 million per year. This is little more than one per cent of total current annual research and development expenditures by the federal government.

The North Carolina Legislature, however, recently appropriated $24.4 million for our Microelectronics Center. Why? Because the members of the legislature saw the connection between the Center and better jobs for our citizens.

Our legislature also is providing nearly $20 million per year for agricultural research and development, four times the federal expenditure for agricultural research in our state. Why? Because members of our legislature know that we cannot increase agricultural production without such research. The dollars we spend on agricultural research result in increased production on our farms. Translated into return on investment in research, each such dollar earns between 35 and 70 cents per year in increased productivity, a very good rate of return on investment indeed.[1] Farmers know this and farmers vote. Legislators know that farmers vote.

A broad-based program of technological innovation will be, among other things, that process by which citizens see and feel the benefits of research. If states deliberately ensure that the results of research are used for the benefit of citizens, legislators will provide the support. Citizens will insist that they do so. Congress also will help.

IV. GUIDING PRINCIPLES

I close now with the suggestion that technological innovation be construed as more than an end in itself. The larger purpose of innovation may be expressed as "meeting the needs and desires of people." Determination of needs and desires is a function of the values and beliefs of people, and of political and economic processes. The emerging crisis I have described is a reflection of such concerns and desires. Government--and particularly state government in partnership with academia, industry and people--has a clear responsibility in resolving this crisis.

Any partnership, however, runs the danger of becoming a collusive arrangement whereby one or more partners "rip-off" other members, or whereby all partners conspire to take unfair advantage of those outside the partnership. Therefore, principles of integrity and purpose must be agreed upon explicitly. Provision for debate, negotiation and periodic review are essential.

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[1] Cf. Robert E. Evenson, Paul E. Waggoner and Vernon W. Ruttan, "Economic Benefits from Research: An Example from Agriculture," Science (Washington: AAAS, Vol. 205, Sept., 1979) p. 1103.

To forge the partnership required, and to establish durable operating principles, each state will likely find it necessary to reach beyond the domain of science and involve those versed in other relevant fields of knowledge and experience.

Let me put this reasoning in philosophic terms: When we forge and implement an important policy decision affecting much of society, we integrate forms of knowledge, factual evidence, values and beliefs. Good or bad, a policy decision is what it is. But I operate under the assumption that our policy decisions are better decisions when we make full and effective use of scientific knowledge. This is why I feel so strongly about the importance of our scientific and engineering community, and why I welcomed the opportunity to meet with you tonight. It is also evident, however, that integrity, purpose, ethical and aesthetic values and other considerations are essential in policy formation.

Alfred North Whitehead stated the matter succinctly in noting that "When you understand all about the sun and all about the atmosphere and all about the rotation of the earth, you may still miss the radiance of the sunset."[1]

A lot has been said and written about what the Reagan administration calls the "new federalism." Like it or not, the relationship between the federal government and states is undergoing a radical shift, a shift that has far-reaching implications for the advancement of science. This is the organizational frontier of science today. In light of these new realities, it is more important than ever that state governments take a leadership role.

And again I say, those of you who, for the benefit of humanity, devise the organizational and technical means by which we master the processes of technological innovation will also reap the rewards of political and economic support inherent in the fundamental desires of the American people.

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[1] A.N. Whitehead, Science and the Modern World, (New York: The Macmillan Company, 1925) p. 199.

Mr. LUNDINE. Thank you, Governor.

Mr. HUNT. Thank you.

Mr. LUNDINE. Now, Dr. Malone, if you would resume—and the chairman can resume the chair.

Dr. MALONE. The timeliness of this examination of international science and technology is underscored by the fact that the next 50 years will probably be the most critical in the 50,000-year record of civilization. The population will double, and if our capacity to provide the goods and services to sustain life and give meaning to existence is achieved, it will be a tremendous challenge for our world scientific enterprise of which we constitute something like 20 percent or 30 percent.

Mr. Chairman, since I have submitted material for the record which with your permission might become part of the hearings, I would restrict my present remarks to three aspects of the IIASA issue which Mr. Brown brought up, which I think are fundamental and which our Commission has explored in detail.

First is the scientific quality of the Institute's work. We have in our academy an advisory committee, which Dr. Penner chairs which continually monitors IIASA's research. In addition the National Science Foundation has commissioned special evaluations. Also, we have comments which have been submitted from alumni who have participated on the IIASA activities. Finally, we have the enthusiasm of our European colleague for maintenance of this enterprise.

I would say that not only has there been a constant assessment but constructive recommendations. The new Director, a Canadian, Dr. Holling, and the Deputy Director, Dr. Hirsch, from the United States, are constructing a program which is responsive to those suggestions. So on IIASA's scientific quality we are completely comfortable.

Second is the uniqueness of IIASA as an institution. It has been built up over a period of 10 years. It is unique in that it is nongovernmental. It can illuminate issues that then can be resolved in intergovernmental fora. English is the language. It is attracting the interest of Mexico and India, Japan is a member, and even the People's Republic of China has indicated an interest in joining the Institute's activities.

I would say that, from the standpoint of considerable experience with other nongovernmental organizations of voluntary workers, IIASA fulfills a unique need in that it permits a concentrated effort at some of the large global problems. Professor Penner can speak to those.

The third issue that I am sure you are conscious of, as are we, is the issue of national security. As a congressionally chartered institution, the Academy is keenly conscious of its responsibilities in this matter. We have entered into an active dialog with the national security community. A subcommittee of our commission on international relations, composed of members with security clearances has examined the documentation addressing national security issues. There are also active conversations between President Press of our Academy and the Director of the IIASA on this point and I discussed these same issues last Wednesday in Vienna with the Institute's Deputy Director. So, we are very actively pursuing them.

The first issue we are looking at is the abuse of IIASA as a base for espionage. Last year, a Soviet staff member serving as Secretary to the IIASA Council was accused in a news magazine of espionage not involving the Institute itself. When that was ascertained, within 3 days the individual resigned and returned to his own country because the spirit of the Institute had been violated. I believe that Dr. Roger Levien, IIASA's Director, deserves credit for taking only 3 days to resolve this problem.

The second issue is the use of the computer, which is a supportive facility and it involves the issue of technology transfer. We have examined this question in detail and feel that it is a practicable problem, one which can be handled with some modest changes in procedures, changes which are already in effect.

A third issue is the selection of staff. We were delighted that Dr. Holling, the new Director, has instituted a rigorous peer review system for the selection of staff from all countries.

The fourth issue is the flow of knowledge at IIASA. In the comments we have supplied to you, you will see there is a general opinion that there is a fair exchange of information. As an anecdote to support that, Dr. Holling described to us a week ago yesterday, when he was here meeting with our Commission, a problem of modeling stochastic processes involved in sorting out competitive technologies. He turned to Mr. Joel Cohen, who had been awarded a MacArthur fellowship, and some of the best minds in this country, and they were not able to crack the problem. It was turned over to IIASA scientist Yuri Ermolev, of the Ukrainian Academy of Sciences' Institute of Cybernetics at Kiev. Within days an elegant solution was developed and made available to IIASA. It is now incorporated into IIASA's work.

I would say in summary of the national security issues that we feel that these are tractable, that is they can be handled. Our best protection is the conscience and the quality of individual scientists who have an ethic of their own in these matters and a highly developed sense of national security.

The present situation is that we need to make up our mind on continued participation in IIASA by June 1. The IIASA Council is so interested in having the United States continue participation that it has recommended a revision of membership dues which will substantially reduce the U.S. contribution and bring it to a level closer to the dues paid by the other members.

Our Commission on International Relations, persuaded of the value of the Institute and the uniqueness of it as a means of getting on with the resolution of crucially important global issues, is recommending to the NAS Council that we remain a member at the reduced level of dues. The Academy will inform you of the action which the Council takes on this recommendation.

With me is Professor Penner. If you would like to hear a few comments about the specifics of the IIASA program, I think he can tell you about some of the more important things they are doing.

Dr. **PENNER**. Thank you, Mr. Chairman. It is somewhat difficult after listening to Governor Hunt not to be tempted to talk about IIASA in the context of technological contributions to the United

States. Of course, it is not a technology institute; it is a systems analysis institute. Yet some of the studies that have been done there are really very beneficial to us also in a technological sense.

The studies at IIASA fall into two categories: A variety of smaller studies and the large studies or programs with a policy content addressed to decisionmakers.

Perhaps I will take one of the latter as an example and then come back to this technology issue. The IIASA global energy study, which is described in the manuscripts which Dr. Malone has submitted to you, is the first careful effort to develop a worldwide consistent global energy scenario. All the national plans are consistent with the regional plans and with the global plan so that one can talk, I think, in a meaningful way about a long-term global energy plan.

The inputs into this study are national plans typically provided by the national member organizations, and I might mention peripherally here that when this study began, there was no U.S.S.R. energy plan available anywhere. It was really under the prompting of the need to complete this study that the U.S.S.R. energy plan for the next 50 years was supplied to IIASA and incorporated into this global plan. I regard that as of an achievement.

We in the United States, of course, have had plans, but not very dogmatic plans, if I may use that phrase. They change, and it is therefore interesting for us to ask what is the IIASA prescription for the United States, in a technological sense, for energy development? We have stringent energy conservation. We know how to do this and we are doing this.

We have another result, though, that is much more problematic, namely that by the year 2000 the United States is not to be an importer of liquid fuels. This means something about the United States, synthetic fuel development, about creating a synthetic fuel industry in the United States that is probably far larger than anything that we have on the docket now. It is a technological stress on our system.

I think in the end the global needs will require us to respond to this, perhaps on a more urgent basis than we have in the past. It is a very useful output for us to know what we have to do in a global context to have demands and supplies balanced over a long time period. This is one example of IIASA's energy study output that I think is beneficial to us.

Another component of this study relates to long-term climatic changes associated with the use of fossil fuels around the world, the carbon dioxide buildup and possible global warming. It is difficult for me to imagine a more sensitive issue on which an East-West dialog is required in order to steer the world onto something like a reasonable course.

If it were to turn out that we have to curtail fossil fuel use, both the policy implications and the economic implications, would surely be staggering. Having a U.S.-U.S.S.R. dialog on this, I am sure, is useful and beneficial.

The IIASA energy program was a pioneer in getting this particular problem examined by the worldwide community. It is a continuing study at IIASA.

I could elaborate on some of the other aspects of this and other studies, but perhaps I will conclude by noting that the IIASA energy study required a careful evaluation of what is really involved in substitution of new technologies for earlier technologies, in particular in the energy field. How long did it take to go from wood to coal to oil to gas? What will it take to go to nuclear and renewable energy resources?

The global time scale here is on the order of 40 years, which is the time needed for a new technology to make a significant penetration. I believe that is a firmly established result of IIASA's research.

A few days ago I was a little bit shocked to get an IIASA document with this methodology applied to car manufacture. While this does not say anything about technology, it says that by 1982, meaning the current year, Japanese production will account for 50 percent of worldwide production, and by 1996 for 90 percent. To reverse that trend will take technological measures of a truly heroic nature.

Thank you for your attention. I appreciate the opportunity to talk on this, but I will be happy to comment on other technological issues as well. Thank you.

[The prepared statement, plus additional material submitted by Dr. Malone, follow:]

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TESTIMONY OF

DR. THOMAS MALONE, FOREIGN SECRETARY

NATIONAL ACADEMY OF SCIENCES

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

FEBRUARY 23, 1982

TESTIMONY OF

DR. THOMAS MALONE, FOREIGN SECRETARY

NATIONAL ACADEMY OF SCIENCES

Thank you, Mr. Chairman, and members of the subcommittee for the opportunity to discuss the issue of the United States participation through the National Academy of Sciences (NAS), in the International Institute for Applied Systems Analysis (IIASA) of Laxenburg, Austria.

As you know, the Institute is a non-governmental research organization which was established in 1972 at the initiative of the U.S. Government to study the common, and complex, problems of modern societies, using the tools of modern management. The National Academy of Sciences was asked by the Government to serve as the U.S. national member organization in IIASA with funds supplied by the National Science Foundation. Sixteen other scientific institutions, representing the Soviet Union, Japan, Canada, and most of the nations of Western and Eastern Europe, joined the NAS in this unique experiment. The Soviet Academy of Sciences, which represents the U.S.S.R., is an equal partner of the NAS in the Institute. Each contributes, in Austrian Schillings, approximately 23.5% of IIASA's total dues budget of about $10 million per year, while each of the other fifteen members contributes about 3.5% of the total.

The Institute's founders, who included former National Security Advisor McGeorge Bundy and the late Philip Handler, President of the NAS, gave IIASA three objectives: to strengthen international collaboration; to contribute to the advancement of science and systems analysis; and to achieve application of the Institute's research to problems of international importance. For the first eight years of its life, the Institute made steady progress toward these objectives under its first two Directors, Dr. Howard Raiffa of Harvard University and Dr. Roger Levieu, now with Xerox Corporation. Dr. Raiffa and Dr. Levien, with the unanimous support of IIASA's governing Council representing all seventeen of the Institute's members, built an international research staff of approximately 100 scientists, each of whom served for a limited period, and a dynamic research program covering such diverse yet interrelated subject areas as energy systems, food and agriculture, resources and environment, management and technology, system and decision sciences, and human settlements and services.

Throughout these years the Institute was under careful scrutiny from our Academy, through its Advisory Committee on IIASA, and its representative on the Institute's Council, and from the National Science Foundation. The Academy has been extremely pleased with IIASA's progress. And thorough evaluations of the Institute's work by the NSF in 1978 and 1980 resulted in favorable reviews by the evaluators and in their recommendation that the National Science Board continue support of U.S. participation. For the information of the subcommittee I am submitting for the record copies of a selection of excerpts from papers prepared as elements of those evaluations.

Despite such reviews, however, the National Science Foundation, citing budgetary stringencies, decided in early 1981 to discontinue its support of the Academy's membership in IIASA at the end of that year. While announcing this decision, the Director of the NSF nevertheless acknowledged the high quality of IIASA's work in testimony before this subcommittee. The reaction to the Foundation's decision was strong and swift. NAS President Handler protested the Foundation's position in letters to NSF Director Slaughter, OMB Director Stockman, and Secretary of State Haig, as well as in testimony before this subcommittee. Several Western European Governments urged the Administration and the Foundation to reconsider; and friends of the Institute among the U.S. scientific community sent several hundred letters supporting U.S. participation in IIASA to NSF Director Slaughter and to Members of Congress. I am submitting for the record excerpts from a few of the letters from American scientists. The result, which followed strong expressions of support for IIASA from committees in both Houses of Congress, was a reversal by the Foundation and a new decision to pay the Academy's 1982 membership dues of 36 million Austrian Schillings.

Nevertheless, the Foundation's reversal was, in fact, only a temporary deferral: in October 1981 the Foundation advised NAS President Frank Press that budget reductions would force it to end its support of U.S. participation in IIASA after 1982. When the Academy's representative on the IIASA Council, Dr. N. Bruce Hannay, informed the Council in November that, because of the Foundation's decision, the Academy would be forced, under the Institute's Charter, to give the required one year's notice of its intent to withdraw as a member, the other members of the IIASA Council took several actions designed to avoid the Academy's withdrawal. First, the Council extended the deadline for receipt of the Academy's notice of withdrawal from 31 December 1981 to 1 June 1982 and agreed that the NAS would not be liable for 1983 dues if the Academy submits a withdrawal notice by 1 June. Second, the Council agreed to re-examine its membership dues structure so as to reduce the ratio of dues paid by the U.S. and Soviet Academies to those paid by the other fifteen members, currently about 6.7 to 1. IIASA's Director was also asked by the Council to propose by 31 March, a 1983 research program at a reduced level of dues support. I am submitting for the record the full text of the resolution adopted by the IIASA Council in which these actions are listed.

Meanwhile, two other events occurred during 1981 which affected U.S. perception of the Institute. The first created an undeniably negative impression. I refer to the allegation which appeared in the British magazine Now that Dr. Arkady Beloserov, the Soviet Secretary to the IIASA Council, had engaged in espionage involving Norway's North Sea oil facilities. Although the allegation involved Dr. Beloserov's activities outside the Institute and no claim was made that IIASA itself was in any way implicated in the incident, the Academy, as the U.S. member, was nonetheless greatly concerned. Our concern, however, was promptly assuaged by the actions taken by IIASA's then Director, Dr. Levien, to obtain immediately Dr. Beloserov's resignation and to secure the unanimous support of the IIASA Council for this action, including that of its Soviet Chairman, Dr. Jermen Gvishiani. Still, this incident appears to have incited concern among some government officials over the security implications, particularly for the transfer of technology, of continued U.S. participation in IIASA.

The second event was, for the Institute as well as for the Academy, a very positive sign. The IIASA Council, again acting unanimously, approved the Canadian and United States nomination of Dr. C.S. (Buzz) Holling of the University of British Columbia as the Institute's next Director. Dr. Holling, who succeeded Dr. Levien on 1 December for a three-year term, is a highly respected animal resource ecologist, well known for his work in the North American scientific community, who had earlier served as an extremely successful and dynamic leader of IIASA's ecology project. Dr. Holling will be assisted in his management of the Institute by the U.S. nominee for Deputy Director, Dr. Allen Hirsch, who is on leave as Director of EPA's Environmental Protection and Effects Research. Dr. Hirsch assumed his post as Dr. Holling's principal executive Deputy in January of this year.

The appointments of Dr. Holling and Dr. Hirsch have given me, the Academy's Advisory Committee on IIASA, our representative on the IIASA Council, and our Commission on International Relations, which I chair, renewed confidence in the scientific potential of the Institute. In response to the offer by the IIASA Council to consider changes in the Institute's dues structure, Academy President Frank Press asked the Commission and the Academy's Foreign Secretary to develop recommendations for action by the Academy's Council at its forthcoming meeting on 28 February.

A "cleared" subcommittee of Commission members has met to review a classified document on the Institute, prepared by the Central Intelligence Agency, and has concluded that continued U.S. participation in IIASA, in their view, would not be inconsistent with national security, although it would require sensitivity to security matters by the NAS and by the Institute's Director. The full Commission has also noted the continued support of the Institute by its other national members, including Austria whose Chancellor has recently written to President Reagan urging continued U.S. participation. In its discussions the Commission has affirmed the value and uniqueness of IIASA as an instrument for international scientific cooperation which has produced excellent research and has made real contributions to the understanding of major global issues; and it has concluded that, under Dr. Holling's leadership, the Institute shows continuing promise.

After completion by the Academy Council of actions on the Commission's recommendations, I will send you a supplementary statement communicating the Academy's decisions regarding continuation of U.S. membership in IIASA, including financing and other aspects.

To provide further background on the Institute and on the issues which now face it, I am submitting for the information of the subcommittee a briefing paper prepared by former IIASA Director Roger Levien.

I am also submitting a list of several of IIASA's accomplishments which, I believe, support the action taken by our Commission on International Relations affirming the quality and significance of the Institute's research. Let me highlight just a few of IIASA's activities of particular interest to the U.S.

First, IIASA announced in early 1981 the publication of a report entitled "Energy in a Finite World" on the results of a seven-year study of the world energy dilemma. The objective of this research, which involved 140 scientists from 20 countries, including the U.S. and the Soviet Union, was to provide new insights into the international and long-term dimensions of the energy problem over the next fifty years. Valuable data for this study was provided by the Soviet Union. According to Dr. Alvin Weinberg of the Oak Ridge Institute for

Energy Analysis, it is "the only authoritative scientific analysis of the world's energy future."

Second, an IIASA scientific team, including U.S. members, and led by IIASA's new Director, Dr. Holling, has developed and published a novel approach to the design of policy for environmental management, known as the "adaptive approach." Since its development, the U.S. Fish and Wildlife Service has established its own adaptive assessment group in Fort Collins, Colorado, to carry this work forward.

Third, the U.S. Department of Agriculture and Michigan State University are working closely with IIASA to develop a comprehensive model of U.S. agriculture as the American component of IIASA's major research program on food and agriculture. This program, which will cover about 85% of the world's population, seeks to define alternative policies at national, regional, and global levels to alleviate existing and emerging food problems. USDA has contributed some $100,000 to Michigan State for development of the U.S. model, plus an additional amount in staff time devoted to the project. By contributing to the development of this model, USDA hopes to improve its own capability to analyze the world food situation.

Fourth, the U.S. Forest Service is contributing funds, staff time, and its own research findings to the Institute as part of a study by IIASA of problems faced by the forest product industries. The Weyerhaeuser Corporation is also supporting this work, and the National Forest Products Association has a strong interest in its progress. The Forest Service believes that the IIASA study will help meet its continuing need for international collaboration in the development and refinement of models and data pertaining to the forest industry.

In only nine short years, the Institute, operating with a limited budget, has made significant contributions to science and to the better understanding of important international issues. It offers the potential of continuing progress in the future, despite a reduced budget. What will happen to this potential if the United States ceases to participate? One possibility is that the Institute will collapse. Another is that the Institute will continue without the United States. Several countries, including our neighbor, Canada, have indicated that they will remain in the Institute whatever the United States decides. But an IIASA without the United States would be a very different place from the Institute which exists today. In either event, the United States will have sacrificed over $16 million in dues paid to the Institute since 1972 and years of effort by American scientists to establish and nurture its research. Neither of these possible consequences of U.S. withdrawal would seem to me to be in the interest of this country.

In closing, Mr. Chairman, I would like to recall for you a novelette written in 1953 by the late Leo Szilard entitled The Voice of the Dolphin. In his book, he described an international organization, called the Vienna Institute, which had been established during a time of reduced tension between the United States and the Soviet Union. The purpose of the Vienna Institute was to build bridges between East and West around the focus of shared scientific questions. It survived and flourished until, at a time of growing political conflict, the U.S. withdrew its support, followed by the U.S.S.R. But happily for this fictional institute, it had developed a magical food substitute, the patenting of which brought returns sufficient to allow it to continue and to work toward its larger purpose of helping bring about world peace.

Unlike Dr. Szilard's Vienna Institute, IIASA has no wonderous patents. It must depend upon its national member organizations to provide the resources necessary to its survival. But, like Dr. Szilard's institute, IIASA has become a very special place; a place where scientists from East and West, and from North and South, work together, without political rancor, toward a better understanding of international problems. There are very few such places in today's world. In the interest of future generations, I urge that the resources be found to keep this oasis of hope alive.

Thank you, again, Mr. Chairman, and Members of the subcommittee for this opportunity to present my testimony. I will try to answer any questions you may have.

NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL
2101 Constitution Avenue Washington, D.C. 20418 USA

COMMISSION ON INTERNATIONAL RELATIONS
Cable Address: NARECO
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February 19, 1982

EXCERPTS OF LETTERS FROM

U.S. FRIENDS OF IIASA

The National Research Council is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering to serve government and other organizations

Allen V. Kneese
Senior Fellow
Resources for the Future

"The opportunities provided by IIASA for international scientific research and exchange are unique. If the Institute is allowed to die...I am confident that a similar institution could not be reestablished in my lifetime.

"In many ways, collaborative work with our friends in Eastern Europe who badly want and need ties to the West, have been most fruitful. Poland and Hungary, for example, have been very active in the organization."

Stephen C. Schmidt
Professor
University of Illinois at Urbana Champaign
Department of Agricultural Economics
College of Agriculture

"I have spent a year of sabbatical leave in 1976-1977 at IIASA which provided half of my financial support in the form of an appointment as a Visiting Scholar. During my stay I have participated in the conceptualization of IIASA's Food and Agriculture research program and modeling efforts and my IIASA experience permitted the development of a new course entitled International Agricultural Trade. This course has since become an integral part of the academic program at the University of Illinois...

"Upon its completion, I intend to use IIASA's Global System of Food and Agriculture model to trace the effects of a set of policies on world food markets in general and on U.S. agricultural trade in particular. These findings, in turn, may serve as a basis for appraising export market potentials for Illinois agriculture as well."

Mark E. Hanson
Assistant Scientist
University of Wisconsin - Madison
Energy Research Center

"I personally have benefited from my work at IIASA in terms of the applied problem-solving research experience that I received. That experience, in regional energy and environmental systems management, has been invaluable in my subsequent teaching at the University of Wisconsin-Madison. The IIASA research, part of which included a study of the state of Wisconsin, has had a marked impact on energy policy in the state."

Gail R. Wilensky, Ph.D.

"As a health economist who has worked both inside and outside of government, I have been impressed with the quality of researchers associated with the IIASA and with the relevance of many of the IIASA projects with policy oriented research being pursued in the U.S. Two years ago, I had the privilege of attending a health care systems modeling workshop sponsored by IIASA...As a result of that workshop and related contacts I was put in touch with several individuals in the Netherlands, West Germany, and Australia whose work was related to several of my own studies and whose advice has helped me proceed more quickly than would have otherwise occurred."

Stephen M. Robinson
Professor
University of Wisconsin-Madison
Department of Industrial Engineering

"A question that one might very reasonably ask is, 'Why would 3 million dollars per year necessarily be better spent on IIASA than on some other comparable scientific activity?' To help answer this, I would like to point out two facts. The first is that IIASA has consistently been able to attract high quality scientific workers from the many countries that participate in it. Thus, there is no question about whether they can do first class work: they have done it, and are now doing it. The second point,... has to do with the issues of position and legitimacy in attacking major international systems issues. It is not difficult for a single investigator, or a small group of investigators, to work on a relatively small, well-defined problem. The kinds of problems that IIASA was set up to tackle, however, are quite different. First, they are big. They involve masses of data, some of which must be collected from one country and some of which must come from another. They involve the cooperation of scientific ministries of departments in different countries. They require sustained effort over a long period of time, and access to the best quality of scientific advice in a number of different fields. There are very few research centers or organizations which can bring to bear, over a period of time, the necessary financial and scientific resources and at the same time deal closely with scientific and governmental agencies in several countries to obtain the necessary cooperation. IIASA is such an organization, and it is because of its unique advantages in successfully attacking multi-national issues that I think it is very important to preserve it."

Mark Thompson
Assistant Professor of Health
  Services Administration
Harvard School of Public Health
Center for the Analysis of Health Practices

"There is no better, healthier, institutionalized interchange of scientific ideas between East and West anywhere that is better than that that has come to pass at IIASA. In comparison with United Nations institutions (I have served as consultant to the IAEA, UNESCO, and WHO), I have no hesitation in judging that the U.S. gets much more from IIASA at a fraction of the cost."

Pierre Crosson
Senior Fellow
Resources for the Future

"Like me, many American scientists in a wide range of disciplines have benefited directly from professional contacts made possible through participation in IIASA programs...Our contribution is a small investment which already has paid off handsomely and promises more for the future."

Carol M. Newton, M.D., Ph.D.
University of California, Los Angeles
Department of Biomathematics
UCLA School of Medicine

"An international ecological research team under Professor Holling of Canada, which included some IIASA-supported U.S. scientists, was developing important new concepts, such as resilience, that should have considerable applicability to utilization of our natural resources. One of the problems addressed as a paradigm under this program was the serious losses our country's northeastern lumber industry suffers because of budworm predation on the balsam forests. It was shown that elimination of the budworm would be virtually impossible, but that a certain harvesting and planting strategy should enable us to maintain a cyclical equilibrium with the budworm in which our economical yields should be maximized over time, and substantially better than at present. As I understand it, this strategy is now guiding practice and in time we shall be able to assess its effectiveness...IIASA scientists investigating resilience have discovered a principle that should be of interest to the present executive branch of our government: It appears that ecological systems that are too tightly regulated, whose numbers vary little over time, tend to be less able to survive unexpected major stresses — i.e., they have poor 'resilience.'

"...There was, indeed, abstract theoretical work, but it was for the purpose of developing tools that subsequently could be applied to real, complex problems. For instance, when one progresses to large systems with many parts that interact (e.g., as in ecology), we now know that extensions of a once somewhat-ignored technique developed by a Russian, Lyapunov, may be the only way to crack the problem of stability analysis. From the very outset, IIASA theoreticians made important contributions to the application of this technique."

Kenneth C. Hoffman
Senior Vice President
Energy and Environment
MATHTECH

"...I would like to call your attention to other benefits of U.S. participation in IIASA which are of direct interest and value to my firm and to similar U.S. firms that market computer software and methods. IIASA programs are generally at the cutting edge of computer methods and enjoy a wide international following. This work and the meeting ground provided by IIASA represents a significant potential market for our services. We are experiencing increased competition in developed and developing countries from French, German, and Japanese firms offering these services and will be at a severe disadvantage in these markets if the U.S. withdraws from its leadership position in institutions like IIASA."

Wesley K. Foell
Director
Engineering Research Center
College of Engineering
University of Wisconsin-Madison

"IIASA has been of tremendous value, for example, to my state of Wisconsin in the field of energy, through an ongoing collaborative systems and policy analysis program which dates back to 1974. In that year IIASA began a pioneering program which examined alternative energy and environment futures for several widely differing regions of the world, including the state of Wisconsin, the Rhone-Alpes region in France,

Wesley K. Foell
University of Wisconsin - Madison
(Continued)

the GDR, and Austria. Out of this work came a deeper insight into energy strategies and policies for both the private and public sectors, as well as a set of powerful forecasting and planning tools. Many of these have been incorporated directly into Wisconsin state agencies and industries, and are in use today. Since 1974 a large number of scientists, consultants, and state officials from Wisconsin have participated in that IIASA program."

George S. Hammond

"...The Institute has become a first class scientific institution producing reports of very great value. Data input to these reports includes important economic and social information from the Communist countries which could not be obtained by any other mechanism."

Donella H. Meadows
Associate Professor
Environmental Studies Program
Resource Policy Center
Dartmouth College

"...I find IIASA to be one of the most valuable international and interdisciplinary institutes in my field. It makes possible contacts with scientists from East and West Europe, information about energy and agricultural and economic systems, and methodological ideas that I have subsequently used for resource management policy for New England and the United States as a whole."

Peter E. de Janosi

"I spent two years at IIASA (1977-1979) and found the experience an exceptionally fruitful one professionally and personally. The open atmosphere among staff is remarkable and it enables participants to learn significantly from each other. At times we learn from the Soviets, at times they from us--for example, distinguished American applied mathematicians found working with their Soviet counterparts productive as Soviet thinking in many areas of mathematics is more advanced than ours. Some of these mathematical techniques have many potential practical applications in business and government."

Joel E. Cohen, Ph.D., Dr. P.H.
Professor and Head
Department of Populations
The Rockefeller University

"IIASA contributes importantly to the well-being of the U.S. and of the world. It is alone among international institutions in bringing to bear the most advanced techniques of mathematics, engineering and the social sciences on the world's pressing problems: energy, food, population, and environment. I worked at IIASA in 1980. For the individual scientists like me who are lucky enough to join the effort. IIASA is a unique international trading ground of points of view, information and techniques of research."

John P. Holdren
Professor of Energy and Resources
Vice Chairman, Federation of American Scientists
University of California, Berkeley

"The problems that IIASA is addressing are among the most important problems humans face; and the people IIASA has assembled to address them have included many of the most competent and thoughtful analysts of these matters to be found anywhere. ...I would contend that the Institute has made and is making important headway in focusing sustained, international, interdisciplinary scientific attention on a set of crucial problems that cannot be understood or solved by narrower efforts.

"There has never been, nor is there now, any other international, collaborative scientific institution tackling these problems with IIASA's diversity of talent and breadth of substantive and geographic scope."

W. David Penniman, P.E., Ph.D.
Director
Development Division
OCLC

"During 1977 I worked at the International Institute for Applied Systems Analysis (IIASA) in Austria. My twelve months there working with other scientists from a variety of countries on difficult problems concerning international computer/information networks has helped me to deal with similar issues in the U.S. arena. I gained vital experience in dealing especially with the socio-political and economic issues of networking technology while at IIASA and this experience is now benefitting my U.S. employer."

B.I. Spinrad
Professor
Department of Nuclear Engineering
Oregon State University

"I have first hand experience with IIASA, having spent my sabbatical leave in 1978-1979 there. I had just about completed my work for the NAS/NRC CONAES study, which concerned U.S. nuclear futures in the context of other energy systems; I was on the Steering Committee of CONAES, and was one of the principal drafters of the final report. Going from there to IIASA, where I helped prepare the voluminous final report of their Energy Policy Project, 'Energy in a Finite World—A Global Systems Analysis,' permitted me to bring the world view back to the U.S."

Roger Wets
Department of Mathematics
University of Kentucky

"My own activity in the area of 'Decision making under uncertainty' has been greatly stimulated by the problems studied and analyzed at IIASA. Motivated by their need for decision models for problems involving parameters about which only limited information is available, some of my colleagues, my students and myself have started working on a new down-to-earth approach to (stochastic) optimization problems."

William W. Cooper
Foster Parker Professor of Finance and Management
The University of Texas at Austin

"Until 1978, I had only the kind of general knowledge of IIASA that was common to many others in the field of operations research/management science and system analysis. In that year, however, I accepted an engagement as part of a six-man team to conduct an on-site audit and evaluation of IIASA on behalf of NSF. My special task involved reviews and evaluations of the actual applications undertaken by IIASA both with respect to their social significance and their use, and possible contributions to the states of OR-MS and Systems Sciences methodologies and concepts.

"Beginning with a skepticism that I deliberately cultivated for this prupose, I gradually came to a positive conclusion on the basis of the evidence I compiled and cross-checked both at IIASA and elsewhere. You might be interested to know that this included a comparison with the East-West Institute supported at a much higher level by the U.S. Government in Honolulu. IIASA came out very far ahead in this comparison and in almost every other way that I could conceive in the form of the cross-checks I used."

Charles ReVelle
Professor
The Department of Geography and Environmental Engineering
The Johns Hopkins University

"I know and use particularly IIASA contributions to environmental planning and research, energy planning and research and to urban and regional science. My colleagues also draw upon IIASA research results in their work."

Glenn L. Johnson
Professor
Department of Agricultural Economics
Michigan State University

"...It is difficult to understand Michigan and U.S. agriculture anymore without an understanding of international trade in agricultural products. IIASA's FAP model offers a model component for analyzing world trade which is superior to that in any other world trade model of which I am aware. What we needed was a better, more comprehensive model of U.S. agriculture so that we could take advantage of IIASA's trade component to analyze our trade, production, resource investment and agricultural pricing policies.

"IIASA is helping us produce such a model."

D.P. Loucks
Associate Dean
College of Engineering
Cornell University

"...I have had contacts with professional personnel at IIASA since its beginning and have found IIASA to be of substantial value to me and my colleagues working on systems analysis techniques for assisting in defining and evaluating possible solutions and tradeoffs associated with environmental and natural resource management problems. As a source of contacts with professionals in other countries, IIASA has been especially valuable. The superior quality of their own professional staff, which is constantly changing, but also of others who attend IIASA conferences and workshops, is particularly noteworthy."

Earl R. Swanson
Professor
University of Illinois at Urbana-Champaign

"...On two occasions, I have worked in the Food and Agriculture Program at IIASA, once in 1975 and again in 1976. I feel that these experiences have substantially enhanced my own research and teaching in agricultural economics at the University of Illinois."

Kenneth R. Hammond
Professor of Psychology
Institute of Behavioral Science
University of Colorado, Boulder

"...I spent two months at IIASA during 1977 and found that it was one of the most rewarding experiences of my professional life...As a result of my experience at IIASA, upon my return to the USA I immediately initiated a joint program of research involving the National Center for Atmospheric Research and the University of Colorado regarding Denver's air pollution problem."

Myron B. Fiering
Gordon McKay Professor of Engineering and Applied Mathematics
Harvard University

"I was a member of the IIASA scientific staff in its first year of full operation, 1973-74, and have since that time been involved in the endless number of assessments of its scientific value and in research projects and scientific contacts which have emerged from that experience...some of our most valuable research directions in our Environmental Systems Program at Harvard have been derived from the American participation in IIASA. The title of three or four of our current and recent projects, which together represent about 75% of our research funding from outside sources, contain the word 'resilient' or 'robust;' these words were introduced into the vocabulary of our discipline as the direct result of collaboration among participants in IIASA's programs.

"...The objective of the research program, as I understand it to be at the moment, will generate profound changes in the way many scientific models and allocation studies are undertaken, and American participation in such a program is absolutely essential for our own benefit as well as that of the international scientific community.

Robert H. Randolph, Ph.D.
Assistant Director
East-West Center
East-West Resource Systems Institute

"...During my nearly two years in IIASA's Management and Technology Area, for instance, I learned more about other countries' views and approaches regarding problems of global significance (energy, food, technological progress, etc.) than I could ever have learned by reading alone...Furthermore, the personal contacts and institutional links forged in my time at IIASA continue to be of great value both to me as a scientist and to my present institution, the East-West Center."

J.E. Goldman
Senior Vice President and Chief Scientist
Xerox Corporation

"...IIASA is probably the most successful example of international technical cooperation...Their recently published energy study is probably the best one that has been done to date in a field vital and critical to us all...I have seen them bring a high degree of professionalism and technical acumen to attacking a series of problems in which those of us concerned with the management of technology have a great stake."

Tjalling C. Koopmans
Yale University

"...From personal participation in 1974-1975 and subsequent observation I have to regard IIASA as a unique instrument for high quality research on problems of great international bearing and significance."

Alvin M. Weinberg
Oak Ridge Associated Universities

"Recent IIASA study, 'Energy In A Finite World', is only authoratative scientific analysis of worlds energy future. It is a unique contribution that attests to high scientific merit of IIASA work."

George B Dantzig

"...IIASA has made a unique contribution to the study of global resource balances and projections through the use of scientific planning models. It is urgent that this important effort not be diminished.

R.A. Bethe

"...Their energy group has produced the worlds best and most realistic analysis of future global energy demand and supply."

February 19, 1982

SOME ACCOMPLISHMENTS OF IIASA

(The reference of the relevant IIASA publication(s) - for further reading - is given in parenthesis. Copies of IIASA publications are available from the Office of the Foreign Secretary, NAS.)

1. Global Energy Study - for the first time a comprehensive long-term study of the global energy future was made with significant inputs from scientists from East, West, North and South. In looking ahead to the year 2030, the study tries to identify strategies to balance a world with growing populations and energy demands with the energy supplies technologically feasible. In doing this, it investigates all sources of energy - conventional and non-conventional, "soft" and "hard". It identifies the maximum potential of the energy options available and the constraints in introducing them into the markets.

This global outlook allows national planning groups to evaluate their domestic energy policy vis-a-vis a world-wide global picture. The study is already being widely used in energy policy discussions in many countries as a "reference" against which different ideas and perspectives are compared (ER 4, books, etc.).

2. Non-differentiable and stochastic optimization: IIASA has brought together the leading figures in the "non-smooth" or non-differentiable optimization field from the US, USSR, Canada, France, etc. As well as catalyzing considerable developments at the state of the art in this field, IIASA has applied new techniques to two real systems under study in its applied research, where the actual behavioural objective functions are not of the "easy" differentiable form - resource allocation in health care delivery and the international market mechanism in food trade.

This research on non-differentiable and non-smooth optimization represents an unusual blend of methodology and application that not only can assist analysts in providing better guidance for decision makers, but also enriches the stock of basic mathematical knowledge. (RR-78-4, RR-80-23).

3. The past quarter century has witnessed unprecedented economic growth in the Third World. Yet major problems have arisen, some of which are the consequences of the progress itself and may become serious constraints on future developments. The demographic evolutions in these countries are one such problem. In the last five years major developments in the field of demo-economics have been made by a team at IIASA. This discipline, concerned with the interaction between population dynamics (temporal and spatial), is likely to increasingly form the basis for the analysis necessary to understand, and so tackle the serious problems facing the developing nations as well as developed nations. (RR-80-22)

4. The substantial cultural component to questions of risk management (particularly of high technologies) means that cross-national comparisons can yield extremely deep insights for our understanding of the phenomenon. For this reason IIASA's risk studies, which have examined such issues as the perception of nuclear risk and decision processes and institutional arrangements with respect to siting of liquified energy fas (LEG) facilities, have made important new contributions which would have emerged much less soon had they not been carried out at IIASA. In particular, the group has developed a multi;attribute, multi-party descriptive framework for structuring the decision processes in siting LEG facilities in four different countries. (RR-80-18)

5. The fact that agricultural production in the world is adequate for supplying the needs of the global population but that many people are starving, clearly implies that the world's distribution system (broadly considered) is not working effectively. With this in mind, a team at IIASA has been building up a better understanding of the very complex system by developing sets of interlinked national agricultural economic models. The approach, which focusses on defining and specifying models which are built by national groups in a number of different countries, and developing analytical and computational tools to allow the linking of the different models through the international trade process, provides an excellent example of the comparative advantage of the institute - very large teams are mobilized with very modest central resources. First results of the study - which promise to be of even greater value to policy-makers than the energy study - are due during 1982. (SR-81-02)

6. Arising out of studies of ecological systems carried out at IIASA in its early years (the results of which saved Canada hundreds of thousands of dollars in salmon fishery programs and have led to a redesign of forest inventory programs in Canada) have come two important results:

a) a much deeper understanding of pest management issues (Vol. 4 in Pergamon series) and also of the management of human disease systems (forthcoming Wiley book - Conway), and

b) the development of the technique of adaptive environmental assessment and management, which has been adopted by environmental authorities in many countries, most notably the U.S. (ER-1)

Recent examples of use of the environmental assessment approach are:

- the U.S. Environmental Protection Agency in addressing the problem of disposing of drilling muds from off-shore oil and gas development. Despite conduct of a multi-million dollar research program by the EPA, there was lack of agreement among scientists, regulatory agencies, and the oil industry concerning issues and gaps in knowledge. As a result of the use of the adaptive approach the research program has been substantially reshaped to focus on critical needs.

- the U.S. Fish and Wildlife Service in addressing a wide range of issues relating to wildlife management and habitat protection. Among these are water management conflicts in the Truckee-Carson river basin (in cooperation with the U.S. Goelogical Survey), assessment of acid rain problems, management of elk populations, wet-land management in the Prairie Pothole region, and competition between fiheries and water resource development in the Californian delta. In all cases this approach has contributed new insights and positive guidance in addressing the issues involved.

7. The techniques of game theory and classical decision analysis have proved disappointing to many scientists in terms of their usefulness for real world problems. A IIASA team has managed to use refined game-theoretical techniques in a real policy environment - the allocation of costs for common water resources between adjoining local authorities in southern Sweden - and the support of the group was extremely well received by the decision makers involved. (ER-5)

Another IIASA team has developed both the mathematical theory of "satisfying" decision making and its practical implementation in the form of a dynamic interactive decision support system that has been recently applied in several IIASA projects (Forestry, Energy, Food and Agriculture) and transferred to several outside institutions in France, Poland, Germany (Federal Republic), and Hungary.

8. The management of major accidents in large scale technical facilities has come under close scrutiny by an international team of scientists at IIASA. As well as making important cross-national assessments of nuclear accident handling in the aftermath of the "Three Mile Island" event, the group has been able to see certain common aspects between these and accidents on offshore oil rigs: the experience showed that, from the organizational point of view, accidents are not necessarily unique. There are similarities that suggest lessons applicable to accidents in general. (ER-6)

9. One of the most valuable outcomes of the coming-together of scientists from countries with different socio-economic systems that the existence of IIASA allows, is the deep probing by the enquiring scientific minds into similarities and contrasts between different institutional environments and perspectives.

For the group of economists from East and West who collaborate in a constructive spirit at the Institute, the issue became clearer - do not all economies, in spite of their differences, consist of mixed economies to a greater or lesser degree? Certainly (e.g.) Hungary had been sensitive to major shocks on international markets in much the same way as (e.g.) Sweden. In the event, a Swedish and a Hungarian scientist were able to develop some important new ideas in the analysis of "small, open economies".

10. Aspects of water resources (both quality and quantity) have formed a continuing strong line of research at IIASA. Useful new results have been derived in the understanding of eutrophication management in lakes (RR-81-02), as well as an important reference document for those involved in operational water quality management. (ER-7)

In terms of water quantity management, a IIASA group has produced useful results in the hitherto relatively uncovered area of water demand estimation, and the subsequent reconciliation of supply and demand. (RR-78-11, 15)

11. Although the public is aware of problems posed by total population levels, there is less awareness, or understanding, of spatial population dynamics and the problems it can cause. In the developing world, mass migration to the cities is already reaching uncontrollable proportions, and in developed countries (e.g. the U.S.A.) the migration away from the cities (by certain sectors of the community) brings with it a number of difficult new problems. IIASA has managed to carry out a consistent comparative study of migration and settlement in all 17 of its National Member Organization (NMO) countries. Each report has found consideration in its own country, and the comparative assessment is of great interest to a number of international agencies. (RR-78-13, individual RR's)

12. As the above studies, and many others, have come to fruition, IIASA has been beginning to distil the common features into a "craft of systems analysis". The first draft now exists of a "Handbook of Systems Analysis", which is likely to prove an outstanding reference work to practitioners of systems and policy analysis, the whole community of middle level civil servants and policy advisers on whose support future decision-makers will increasingly rely as the issues they have to tackle become more and more complex. If current experience continues, an increasing number of advisers will often be IIASA alumni, and the common understanding of complex international issues that IIASA teams are building and that the alumni in the different countries will share will, in the long term, be crucial for the ability of nations to make progress towards resolving such issues in a cooperative spirit.

As well as promoting substantial international collaboration on problems of importance of mankind, IIASA has, in many countries, had a further significant effect, perhaps less expected by its founders. Cross- and inter-disciplinary approaches of interest in tackling real policy design problems had in 1972 not been very developed in most of IIASA's NMO countries, and in order to facilitate national assessment and liaison for IIASA, new institutions have in many NMO countries been created which fulfil an increasingly important national role in coordinating different systems analysis activities, thus helping to bridge the gap between research and policy.

SELECTED QUOTATIONS FROM THE 1980 REPORTS BY NSF EVALUATORS OF IIASA

Carl Keysen

"IIASA is addressing questions that are both important and intellectually worthwhile." (p. 2)

"The quality of the staff seemed generally high." (p. 5)

"In many cases, the contribution of data from different member countries was central to the possibility of successful work. The studies of migration patterns and population distribution were possible only because of the gathering of data, some previously unpublished, from the participating countries. Similarly, the world food model benefits greatly from the contributions and the variety of perspectives of scientists from the many countries involved." (p. 6)

"There is no doubt that the energy study has been important, and has directly shaped the views of policy makers in Germany, in particular, and in the European community more generally." (p. 8)

"In my judgment, the importance of the (food and agriculture) project is unquestionable; so is its pioneering quality. Successful completion of a truly interactive world production, trade, and consumption model for major agricultural products in enough detail to show the international consequences of various national policy choices, including distributive consequences, would be an accomplishment of great practical value for policy-makers and policy critics as well. It would also be a considerable intellectual achievement in applied economics and econometrics." (p. 11)

"This (Resources and Environment) Area provided a few of the notable examples of successful models which both deepened understanding of the systems modelled and influenced policy choices by decision makers. One of the most striking examples... was the study of the spruce budworm conifer-forest system of eastern Canada and northern United States by Clark, Holling and Jones." (p. 14)

"Given the organizational basis on which it rests, IIASA has done a truly remarkable job of achieving an international spirit of joint scientific effort." (p. 18)

"In my view both its merit and its ongoing political contribution are such as to earn IIASA continuing U.S. support." (p. 25)

George J. Klir

"...IIASA has been successful in recruiting competent scientific staff and,when considering its publications, has produced scientific work of respectable quality." (p. 8)

"Although one can question the methodological foundations behind the IIASA applied research, the accomplishments in applied research are respectable. I was particularly impressed by the work in ecology." (p. 11)

George J. Klir (continued)

"My overall conclusion is that the positive aspects of the international character of IIASA clearly outweigh the negative aspects." (p. 12)

"Although some changes in IIASA are desirable, its existence is significant and its current operation adequate to warrant continued U.S. support." (p. 15)

C. West Churchman

"I believe that IIASA, with its interest in human social systems has become an almost essential organization in maintaining and further developing a common and truly international research concern about the human condition." (p. 2)

"The large problems of human society, such as food, energy, and communications, demand in a very strong way the existence of international systems analysis in order to better the human condition." (p. 12)

Martin Greenberger

"He (Greenberger's friend) told me he had gotten to know the Russians better during his year at IIASA, and had there developed a better understanding of how Russian research machinery works, than he had through his visits and other contacts with the Soviets." (p. 3)

"The kind of international cooperation and understanding that was the main motivation in the creation of IIASA is needed more today than ever before." (p. 28)

"...IIASA has a unique and vital role to play in the study of the world's problems." (p. 29)

Robert M. Thrall

"In brief, I believe that IIASA performance has reached and is maintaining a level which more than justifies its costs in money and other resources." (p. 1.1)

"I regard the IIASA staff as being first class." (p. 2.2)

"IIASA is clearly producing a goodly number of high quality publications (along with some of lesser status)." (p. 3.1)

"...(T)he interaction between staff members from different countries has in the past, and should continue to have in the future, considerable benefits. For example, in mathematical programming and control theory, the state-of-the-art is more advanced in the USSR in some areas and in the USA in others." (p. 3.4)

SELECTED QUOTATIONS FROM THE 1978
REPORTS BY NSF EVALUATORS OF IIASA

W.W. Cooper (Report on Policy Applications of IIASA Products with Analytical - Quantitative Content)

> "Nevertheless, (Andrei) Rogers location at IIASA...provided access to Eastern bloc activities that would otherwise have been extremely difficult to come by. As a consequence, new statistical-demographic practices are likely to be in place and adapted to the requirements of practical contexts much earlier and in a more balanced across country, manner than would otherwise be the case." (p. 5)
>
> "(T)his work (an IIASA report by V. Peterka of Czechoslovakia entitled Macrodynamics of Technological Change: Market Penetration by New Technologies) represents an elegantly formulated theoretical contribution which is capable of further empirical and theoretical testing that goes beyond anything I know of in the present literature on technological change." (p. 8)

C. West Churchman (Survey of the Contributions of IIASA to Methods Other than Applied Mathematics)

> "To me, the most impressive nonmathematical 'technique' which I encountered at IIASA was in the energy program." (p. 6)
>
> "I believe as educational documents that enable students to understand how complex systems are put together these documents (IIASA studies of the TVA Bratsk-Ilimsk and Shinkansen projects) will be highly useful to students." (p. 9)
>
> "...(T)he development of systems science in the last twenty years has been a social experiment and...it will probably take several more decades to produce meaningful information from the experiment. Assuming that it is worthwhile for humanity to conduct such an experiment, then I believe IIASA is one of the stronger elements, because it is probably there that we can most clearly see the global implications of systems analysis." (p. 15)

John Richardson (International Collaboration at IIASA: Survey and Appraisal)

> "Overall, the level and quality of international communications appears to be as high or higher than one might reasonably expect in a setting of this type.... Scientists from the East have relatively few inhibitions about discussing problems of planning and management as well as the cumbersome rules and procedures." (p. 7)
>
> "In my judgement, international collaboration among the central administrative staff of IIASA is more than an aspiration, it is a fact." (p. 9)
>
> "Apparently, scientists from East and West can function cooperatively with tact and sensitivity, in the conduct of difficult management tasks, as well as in research activities." (p. 14)

John Richardson (continued)

"In general, the feeling was that IIASA was doing extremely well, given its circumstances, especially in the area of international collaboration, when compared with academic institutions." (p. 25)

"IIASA's Energy Systems project has been a success by almost any reasonable standard of evaluation and, through its dissemination phase, stands a good chance, I believe, to achieve several major applications." (p. 33)

Jurgen Schmandt (Policy Research at IIASA)

"The work done under the format of the research programs - up to this point in time, energy and food and agriculture - holds promise for policy-relevant work." (p. 1)

"There is also a widespread feeling that the IIASA concept has shown its viability." (p. 14)

"In my judgment, the roll of IIASA in developing research of this kind, working closely with scientific and political institutions in its member countries, is innovative and of direct utility to policy makers." (p. 47)

"(I)nnovative ways for conducting policy research on large socio-technical problems are being developed.... There is promise of significant impact on policy making, both by participating in critical states of policy formulation and by contributing important concepts and analytical results which can be used by policy makers." (p. 52)

"IIASA is the only international research institute for policy analysis.... Institutionally, IIASA is in a unique position to undertake cooperative policy research across boundaries of political organization and philosophy." (p. 54)

A. Charnes (New Analytical Methods at IIASA: Applied Mathematics)

"IIASA has achieved a few notable successes in applied mathematics as well as a significant chain of collaboration and dialogue among individual applied mathematical systems analysts of the National Member Organizations." (p. 6)

"The work of V. Peterka of Czechoslovakia (IIASA Research Report RR-77-22, November 1977, 'Macrodynamics of Technological Change Market Penetration by New Technologies') represents the first real innovation in many years in the theory of technological change." (p. 15)

"Important contributions in various fields of applications have been made in (a) the budworm analysis and simulation of Holling, Ludwig, Jones and Fiering, (b) the national food and agriculture linkage modeling of Keyser, Rabar, et. al., (c) the technological diffusion modeling and theory of Peterka, (d) the climatology papers of Jill Williams, et. al., (e) the demometrics of Rogers, et. al." (p. 18)

"At their best, IIASA's applied mathematics contributions to methods are equal in quality to those of any other groups." (p. 20)

Mr. **Walgren**. We appreciate your views.

That completes the panel. The Chair will recognize Mr. Brown.

Mr. **Brown**. Thank you, Mr. Chairman. I feel somewhat at a loss since I missed the bulk of your testimony. I have tried to skim through it rapidly.

I have been deeply concerned about the problems with regard to the funding of IIASA. I wonder, if you have not already done so in your previous testimony, if you would state for the record what your understanding of the rational for the withdrawal is. I find it a little difficult to feel that a major international initiative of this sort, requiring only a minimal amount of money in any realistic terms, $2 or $3 million, is being terminated only because of a lack of funds. I assume that it is a deliberate action aimed at expressing our desire to withdraw any form of cooperative relationships with the U.S.S.R. If I am wrong, or if you have indicated some other reasons in your testimony, I wish you would correct me on this.

Dr. **Malone**. I have indicated, Mr. Brown, that I think there is agreement on the quality of the work; there is agreement on the uniqueness of the institution. We are all aware of financial pressures. That leaves national security-technology transfer as an issue.

We have examined that in detail now, through looking at classified documents by a panel which had been cleared and do not find that persuasive. However, we are continuing an active dialog with the responsible officials in the Government's security apparatus and hope to reach a positive resolution of the issue in the near future.

Mr. **Brown**. Are you optimistic that the decision will be positive?

Dr. **Malone**. Yes, sir. I should point out, Mr. Chairman, that this is the only institution in which the U.S.S.R. matches the U.S.A. contribution and does so in hard currency. Our share of this is 23.4 percent in each case, which, as you know, is less than the U.N.'s share. It is not out of proportion.

Mr. **Brown**. Dr. Malone, you made some reference, I think, in your statement, as I glanced through it hurriedly, to some revision in the dues structure. Was that contemplated as an alternative to continuation of the present funding scheme?

Dr. **Malone**. Yes, sir. The council of IIASA by resolution proposed that there be a revision in the dues structure to accommodate the financial problems in the United States. This is now currently under way.

At the moment, through the diligent efforts of Dr. Slaughter and his colleagues, for 1982 we have paid dues to IIASA of about $2.16 million. That is matched dollar for dollar in hard currency by the Soviets. We think that U.S. annual dues on the order of $1 million would permit a viable, vibrant program. The new Director, Dr. Holling, has constructed a program around that reduced figure.

We do recognize the need for fiscal integrity. We do share very deeply your conviction that this is really a modest investment in a terribly important problem.

Mr. **Brown**. I have at least surveyed, if not read in detail, the global energy study. I am familiar with some of the other reports that have been completed and some that are proposed. Frankly, I find them to be of tremendous use, presenting a perspective available from no other sources that I know of and lacking in any reasonable relationship to any technology leaks from this country. I just do not perceive it, but, of course, I do not have access to classified information that might contradict that, if there is such information.

I am pleased at your optimistic prognosis. If it does turn out that some reasonable continuation program is arrived at, I would like to be informed as to the process by which that was reached and give due credit to the farsightedness of those who participated in changing that policy decision.

Dr. **Malone**. I would be happy to do so. May I say, Mr. Brown and Mr. Chairman, that in my opinion when one examines the tensions generated by energy issues today and the attempt to get a worldwide view of this through IIASA, when one looks down the road with almost certainty to even greater tensions connected with food supplies and recognizes that is the second major project of IIASA, I am personally deeply convinced that, rather than threatening our national security, this Institution is a contribution to national and international security.

Mr. **Brown**. I would concur in that, Dr. Malone, although I would feel it would be even more of a contribution if the membership of IIASA would be expanded gradually to allow participation by more of the intermediate-level countries. It is rather an exclusive club now, as I understand it.

There is a demand in the Third World for access to technology and information. While we probably are not going to meet it to their satisfaction, at least an entree through an institution such as IIASA might help alleviate some of the pressure.

Dr. **Malone**. Dr. Holling is in Mexico this week discussing their possible participation. Last Wednesday when I was in Vienna, Dr. Mennen, who as you know is the science adviser to the Prime Minister of India, was out at IIASA exploring ways in which they could collaborate.

As an aside, the Chairman of the Council of IIASA, a Soviet, has remarked that it would be quite in order for the People's Republic of China to become a member as long as they subscribe to the same rules that the Soviet Union has lived up to in the last 10 years.

Mr. **Brown**. That would certainly be a constructive outcome of this period of trepidation that we are going through.

Dr. Carey, I gather that your testimony was aimed more at the problems that seemed to be developing with regard to other forms of restricting the flow of scientific and technological information. Do you feel any more optimistic—if the IIASA situation were to be resolved, would it indicate to you the possibility that we might see other signs of improvement in this overall field in the future?

Dr. **Carey**. We are about to enter a seasonal change, the change in the Equinox and so forth, and spring is coming. I would hope that, if there is some relief from the IIASA embarrassment, some other things will follow, but I do not really think it is that simple.

I think we have a state of mind in the executive branch that is very troubling. It is not a question of protecting or not protecting the national security; it is a question of a balance between protection and overprotection.

The reason that I devoted most of my remarks to commenting on the appending Executive order on national security information is because if we do not recognize the implications and the consequences of that type of order, of that type of policy, of that kind of discretionary power distributed through the executive branch of the Government, we may keep our eye on basic science and appropriate more and more for it each year but deny ourselves the benefits. I think it is a very serious matter. I hope very much that the Congress will speak up and express its concerns about the merits of that policy, Mr. Chairman.

Mr. Brown [acting chairman]. I am partial to your position on this, but obviously the solution is that this seasonal change take place in the entire spectrum of research and development and we have a new flowering of innovation and technological progress in this country.

Dr. Carey. That is exactly right.

Mr. Brown. Then we will begin to see some reduction in these pressures to protect ourselves against possible losses, which in my opinion, as in yours, is counterproductive in terms of the national welfare.

I have no further questions of you gentlemen at this time.

Dr. Carey. Thank you, Mr. Chairman.

[The material referred to follows:]

NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL
2101 Constitution Avenue Washington, D.C. 20418 USA

COMMISSION ON INTERNATIONAL RELATIONS
Cable Address: NARECO
TWX #: 7108 22 9589

RESOLUTION ADOPTED BY THE COUNCIL FOR THE INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS NOVEMBER 1981 REGARDING U.S. PARTICIPATION

U.S. NMO Funding Situation

IIASA/COUN-XVII/ Reslu 115

The Council,

having heard the report of the United States NMO that the U.S. National Academy of Sciences (NAS) has been informed by the National Science Foundation (NSF) that NSF will be unable to supply the necessary funds to maintain the NAS membership in IIASA after 1982, and that, notwithstanding its strong interest in remaining a member of IIASA, the NAS would be obliged to inform the Council by December 31, 1981, of its intention to withdraw at the end of 1982 in accordance with the IIASA Charter, barring some changes in circumstance that would allow a different decision to be made,

stating its strong belief in the importance of IIASA as a multilateral institution investigating many of the world's most pressing problems,

emphasizing the conviction that the accomplishments and experiences of IIASA in cooperation with a world-wide network of scientific centers ensure that IIASA can continue to make a unique and irreplaceable contribution to addressing world problems of the deepest concern to humanity,

recognizing the importance of the involvement of U.S. scientists together with those from other nations for the fullest practical realization of IIASA's mission,

expresses its concern and, wishing to avoid the consequences of NAS withdrawal, hereby resolves

to agree, recognizing the necessity to allow sufficient time to explore all options, that, notwithstanding the provisions of the Charter, notice of NAS withdrawal received by the Council before June 1, 1982, will be deemed to have been received by December 31, 1981; so that the Council will not hold the NAS liable for Institute dues on or after January 1, 1983, if, by June 1, 1982, the NAS submits a withdrawal notice;

to consider a substantial reduction in the ratio of category A to category B NMO dues for 1983 and beyond, even if this necessitates continuing the Institute's work in a somewhat reduced and transformed pattern;

to re-examine fully its membership dues structure;

to explore ways of broadening the international base of the Institute;

to reaffirm that untargeted contributions channelled to IIASA through the NMOs from any source will be accepted by the Institute as part of the NMO's membership contribution;

to ask the Director to elaborate by March 31, 1982, a proposed 1983 research program at a reduced level of dues support, together with the changes required in 1982 that will allow a smooth transition. The plan should also identify opportunities for additional research through collaboration with other groups and with the support of supplementary funds.

Executive Summary

Briefing Paper
on the
Need for Continuing U.S. Financial Support for the International Institute for Applied Systems Analysis (IIASA)

o The National Science Foundation (NAS) has proposed to withdraw its financial support ($2.3 million) for U.S. membership in IIASA after FY 82 as a consequence of budget reductions. NSF has supported IIASA as a non-governmental organization by providing funds for membership to the National Academy of Sciences (NAS), the Institute's U.S. member organization. Without adequate funding for this purpose from outside sources, NAS will find it difficult to remain a member of IIASA.

o Withdrawal from IIASA would be a serious loss to the U.S., both scientifically and politically. As an institution for interdisciplinary research on issues of international significance, IIASA is unique. It has made important scientific contributions in energy development, environmental management, food and agriculture, population growth and urban settlement, water resources, and other areas. IIASA is widely judged a success in achieving effective, non-political research collaboration among scientists from East and West, and to some degree from North and South. It enjoys wide international support.

o The NSF budget cut does not reflect adverse criticism of IIASA's research. On the contrary, NSF evaluations have given IIASA high marks. The cut is believed to reflect the fact that NSF prefers grant programs that it itself administers to an activity that is administered through

NAS with relatively little direct NSF involvement or internal staffing commitment. In addition, it reflects a natural higher NSF priority for funding domestic science.

- The Congress has indicated strong support for IIASA. It has added money to the NSF budget for FY 82, to permit continued NAS membership in the Institute.

- Some national security policy questions concerning continued support of IIASA have been raised at staff level in certain quarters of the Administration, reflecting increased U.S.-USSR tensions. However, these arguments have been examined and are believed to be of secondary importance. The State Department has indicated clear support for IIASA.

- At its November 1981 meeting, the IIASA governing Council, representing the 17 member organizations, unanimously endorsed the importance of continuing support for IIASA and of continued U.S. participation. The Council indicated its intention to adopt more flexible funding provisions, explicitly for the purpose of making it easier financially for the NAS to remain a member.

- Announcement of U.S. withdrawal could have profound effects. The likely result would be continuance of IIASA without U.S. membership, which would be counter to U.S. interests. As a non-political institution devoted to tackling important contemporary problems for the benefit of mankind, a U.S. pull-out would have very adverse consequences on America's image. In addition, a prestigious scientific institution largely initiated by the U.S. would continue without American influence. Another possible effect might be the collapse of an important institution that was established as a result of a U.S. initiative.

IIASA has provided an effective opportunity for Eastern European scientists to interact with their U.S. colleagues independent of the USSR. This factor assumes even greater importance in view of recent developments in Poland. With proposed closure of bilateral scientific links with the USSR the possibility of retaining a window into Soviet thinking (and to other Eastern European communities) through continued presence at IIASA is even more important.

- In addition to its already well demonstrated value in fostering cooperative international science activities, IIASA has the potential for demonstrating an effective U.S. follow-up to Cancun. U.S. support for high quality, objective studies of complex development issues could demonstrate to the developing world a positive concern for addressing certain long-range questions raised at Cancun. Mexico is actively considering joining IIASA.

- U.S. Government decisions concerning IIASA, with serious potential scientific and political consequences, appear thus far to have been made largely on the basis of staff level discussions. There has been only fragementary policy level input and inadequate consideration of the full range of impacts. The implications of U.S. withdrawal from IIASA as a result of NSF budget decisions are serious enough to warrent thorough top level discussion and reconsideration.

BRIEFING PAPER
on the
NEED FOR CONTINUING U.S. FINANCIAL SUPPORT FOR THE INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
(IIASA)

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6. CONSEQUENCES OF U.S. WITHDRAWAL
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8. SUMMARY

1. THE ISSUE

The National Science Foundation (NSF) has proposed to withdraw its financial support for U.S. membership in IIASA after FY 82. Without U.S. participation, IIASA may not survive. This paper explains what IIASA is, discusses the background for the proposed withdrawal of financial support, and outlines what the scientific and political consequences of U.S. withdrawal could be.

2. BACKGROUND INFORMATION ON IIASA

o IIASA is an East-West applied research organization, located outside Vienna, and now financially supported by 17 National Member Organizations (NMOs) from the following countries:

North America

- United States
- Canada

(Mexico is actively considering membership)

Western Europe

- United Kingdom
- Federal Republic of Germany
- France
- Italy
- Netherlands
- Sweden
- Finland
- Austria

Eastern Europe

- Soviet Union
- Poland
- Hungary
- Czechoslovakia
- German Democratic Republic
- Bulgaria

Asia

- Japan

The U.S. and the USSR NMOs pay the largest share of IIASA's budget income, amounting to some 23% each, and NMOs from all the other countries each pay approximately 3.5%.

o IIASA's Charter was signed in 1972 after five years of negotiations. McGeorge Bundy from 1967-69 and Philip Handler from 1970-72 led the U.S. negotiation efforts. Negotiations were begun as a U.S. initiative during the Johnson Administration, and the Institute was established during the Nixon Administration. It continued to receive support during the Ford and Carter Administrations. Thus, it has a history of bipartisan support in the U.S.

o IIASA is officially non-governmental: no international treaties were signed; documents do not have to be cleared by governments. It is supported by Academies of Science or similar types of institutions (for example, the Royal Society of the United Kingdom). The U.S. was instrumental in deciding the non-governmental character of the institution. In comparison to other international bodies IIASA is relatively non-bureaucratic, and maintains an informal academic atmosphere. Even the governments of Eastern Europe find it convenient to insulate IIASA from official government involvement.

o IIASA is governed by a Council comprising one member from each of the 17 National Member Organizations. The Chairman is Academician Jermen Gvishiani from the USSR. The U.S. member of the Council, appointed by the President of the National Academy of Sciences, is traditionally the Chairman of the Finance Committee, and a member of the Executive Committee, of the IIASA Council. Academician Gvishiani has performed his task over the whole history of the institution with great skill and evenhandedness as attested to by his unanimous support in three re-elections. The past Directors of IIASA have been from the U.S., and as of December 1, 1981, the Director is a Canadian, with an executive Deputy Director from the U.S., and a Soviet Deputy Director.

o The Austrian government has assumed full financial responsibility for the magnificent restorations and modernization of Schloss Laxenburg, the home of IIASA. Austria has spent over $10 million on these renovations. (Similar facilities in the United States would be far more expensive.) The Institute pays only a symbolic rent for use of the facilities.

o IIASA supports in-house research and coordinates research activities of an external network of scientific institutions within the NMO countries. The collaborative network comprises over 200 institutions, including over 50 in the U.S. It has taken years to build up this network. IIASA hosts approximately 30 international scientific conferences per year. 196 U.S. scientists participated in IIASA's conferences in 1980, exchanging ideas with colleagues from Western Europe, Eastern Europe, and the Soviet Union.

o Approximately 100 scientific researchers, supported by an equal number of support staff (librarians, research assistants, computer service and publications staff, etc.) are present at IIASA at a given time. The vast bulk of the scientific researchers stay for periods of six months to three years.

o The IIASA mission is to:

- promote international collaboration by bringing together scientists of different disciplines, cultures and nationalities to work on problems of concern to mankind.

- advance the sciences contributing to systems analysis, improving analytical techniques and their usefulness in decision processes;

- apply its findings to problems of international importance by providing policy makers with relevant information and appropriate tools for tackling these problems.

o IIASA's primary research focus is on internationally important problems: energy systems, climate, environmental management, population studies, risk assessment, food supply and distribution, and others. Research is done by international, interdisciplinary teams. No research is classified; all IIASA publications are in the open domain.

3. IIASA ACCOMPLISHMENTS

In its short existence, IIASA has already achieved major accomplishments with respect to its mission, as follows:

o *International Cooperation*

- *IIASA is widely adjudged a success in achieving effective, non-political joint work among scientists and engineers from nations both East and West and to some degree, North and South.*

  During 1980, 179 different scientists from over 20 countries were at IIASA for some period.

- *IIASA has also succeeded in building an effective international network of collaborating institutions from over 25 nations, both East and West.*

  During 1980, over 200 institutions collaborated strongly with IIASA's research activities; some 50 from the United States and some 30 from the Soviet

Union; but no fewer than 7 from any IIASA member organization country and, more generally, between 10 and 15 from each. This collaboration is very much stronger than, and indeed qualitatively different from, casual scientific interactions at conferences or through "post box" international scientific organizations like ICSU, IFAC.

- *In addition to its broader international aspects, IIASA is a strong, probably unique, demonstration of a positive, cooperative and mutually beneficial joint activity of the United States and the Soviet Union.*

  Policy discussions in the IIASA Council, under Soviet Chairmanship, have never turned on political issues; it has never been found necessary to have a vote on any resolution. The Director has operated with full support of the Academies of both the U.S. and the USSR.

o *Advance Science and Systems Analysis*

- *IIASA has brought together a uniquely qualified staff drawn from the physical sciences, engineering, operations research and systems analysis, mathematics and computer science, economics and management sciences.*

  Its staff has comprised three Nobel Prize winners (one from the USSR), a U.S. National Medal of Science winner, a Soviet State Prize winner, and members of the national Academies of Science and Engineering of the U.S., USSR, and other nations. It has drawn numerous full professors on leave from major academic institutions in all participating nations.

- *IIASA has succeeded in achieving true interdisciplinary as well as international cooperation in its studies.*

  The Energy Program, for example, employed physicists, engineers, climatologists, economists, mathematicians, operations researchers, resource specialists, demographers, and psychologists. No research group has fewer than four or five different specialists participating.

- *IIASA has contributed significant scientific results in a number of fields and is making major contributions in the development of the "craft" of systems analysis itself.*

Among the fields of science in which its work is highly regarded are:

- *Mathematical Optimization* -- contributions to large-scale linear, "non-smooth", non-linear, and stochastic optimization;
- *Mathematical Demography* -- development of multiregional and multistate mathematical demography;
- *Economic Modeling* -- development of international linked systems of national economic models, solution techniques for general equilibrium models; comparative assessments of "small, open" economies in both planned and market economies;
- *Water Resources* -- state-of-the-art investigations of water demands, supply-demand integration, and uncertainty in water quality modeling;
- *Management Science* -- theories of market penetration of new technologies; techniques of risk assessment and accident management for large-scale technological facilities.
- *Conflict Resolution* -- mathematical theories of "fair" division, game theoretic applications to groups competing for common resources.

(A more detailed list of IIASA's research accomplishments is attached.)

Among its contributions to systems analysis are:

- *Handbook of Systems Analysis* -- preparation of the first of three volumes of an international handbook for policy-making practitioners in government and industry;
- *International Series on Applied Systems Analysis* -- publication of 12 books in a highly regarded series of international state-of-the-art reviews (30 additional volumes are in preparation).

o *Investigate Problems of International Importance*

- *IIASA's research program is focused on the central issues that nations of the world must face and resolve together. It is the only international non-governmental scientific organization with such a program in which both East and West are represented.*

  It is studying aspects of two major international problems - Energy and Food & Agriculture: meeting the needs of a global population that will double in the next 50 years and dealing with the rapidly increasing interdependence among nations due to trade, migration, financial flows and knowledge flows. It is also investigating the problem of development of sub-national regions, which is of interest to many nations.

- *IIASA's research program is of interest to both government and industry in the U.S. and in all the other participating countries.*

  The Energy Study has been closely followed by the *U.S. Department of Energy*, as well as by Exxon, Gulf, Sohio, General Electric, Avco, Air Products, Combustion Engineering, Dresser Industries (all of whom have also contributed supplemental funds to IIASA).

> The Food and Agriculture Study has had the active participation of the *U.S. Department of Agriculture*, which has provided support to Michigan State University to collaborate with IIASA. Financial contributions have also come from Coca Cola, CDC, Seagrams and the Continental Group.
>
> The *U.S. Fish and Wildlife Service* makes extensive use of IIASA's work on assessment of environmental development programs.
>
> The *U.S. Forest Service* has made a contribution to IIASA's three-year study of the world forest industry. Support for this study is also anticipates from Weyerhaeuser, Mead Corporation, International Paper, and other forest industry companies.

As an institution for interdisciplinary research on issues of global significance, IIASA is unique. Unlike most other international scientific organizations, it serves much more than an information exchange function. Unlike many governmental international organizations it has been unencumbered by national positions and polarization, or by stifling bureaucracy. At IIASA it has been possible, through cooperative research and analysis on common problems, to build new insights, understandings and solutions. IIASA's success in this regard is reflected by warm relationships with, and the clear respect of, such United Nations agencies as the World Health Organization, the Food and Agriculture Organization, the UN Environment Programme, and the International Atomic Energy Agency, which have come to see IIASA as a valuable collaborator.

4. FUNDING AND THE FUNDING CRISIS

o IIASA's financial support comes from dues from the National Member Organizations in a two-tier system. The U.S. and the USSR members each currently pay roughly $2.3 million per year and the 15 other NMOs each pay 1/6 of this amount. All dues are in convertible currencies. The USSR has matched the U.S. in its support throughout. IIASA is the only international organization in which the U.S. and USSR pay the same amount in hard currency. The financial support level of the Institute in real dollars is about 2/3 of the amount envisaged by the U.S. in its proposals in the late 1960s.

o The U.S. supports IIASA through the National Academy of Sciences (NAS), which in turn gets this funding from the National Science Foundation (NSF). Originally President Nixon directed the NSF to set up a special line item for IIASA, but subsequently IIASA's funding has been incorporated into that part of NSF's budget dealing with support of international scientific activities.

o IIASA's operating budget from membership dues is about $10 million per year. The U.S. contribution is about $2.3 million per year. About $1 million comes from contract research with various United Nations agencies and from contributions from industry for broad-gauged, non-proprietary studies. There are 16 industrial contributors to the NAS's fund for International Cooperation in Systems Analysis Research, including such companies as Coca Cola, Exxon, General Electric, Xerox. Their contributions in 1980 totaled $250,000.

o By the Charter, any NMO must give IIASA a year's notice of its intention to withdraw its membership. The formal obligation for continued financial support of IIASA by the U.S. rests with the NAS and not with NSF.

o The OMB directed a reduction, in Fiscal Year 1982, in the international activities section of NSF, from $16 million to $10 million, and NSF then decided that support of IIASA should be eliminated from its budget. The proposed elimination of funding resulted in a wide outpouring of support for the Institute. As a result, the Congressional Appropriations Committees have directed NSF to provide the necessary funds in Fiscal Year 1982. Thus, continued U.S. support for IIASA is assured through this year.

o However, in response to even stronger budgetary pressures, the NSF has again indicated to the NAS that it will be unable to fund IIASA after Fiscal Year 1982. The NAS advised the IIASA Council in November 1981 that the NSF was withdrawing its support, and that unless a source of financial support were found, NAS would have to withdraw from IIASA. The IIASA Council's response to this position will be discussed below.

o The NSF has commissioned several independent evaluative studies of IIASA's research accomplishments. These reports have been very favorable overall, with respect to IIASA's scientific accomplishments to date. With respect to fulfilment of IIASA's mission in bringing together researchers from East and West to collaborate on common problems, the reports have also been very positive.

In summarizing a series of evaluations made in 1978, the NSF quoted: "This evaluation has been positive and would warrant continued U.S. support for IIASA. IIASA is a source of benefits to U.S. science and is making good progress toward the achievement of its original objectives." Further evaluations were made in 1980. The NSF reviewers made some recommendations for program improvement, which are currently being implemented by the new Director. In addition, they unanimously recommended continued U.S. support and agreed that IIASA was a unique and valuable institution. An independent 1980 contract study for the NSF assessment stated: "In summary, the IIASA reports continue to represent a substantial body of meaningful research products. With few exceptions, both the theoretical and applied work are considered by the experts to be generally of high quality. Some of the reports generated disagreement among the reviewers, but this is to be expected in as broad a professional community as that covered by IIASA reports."

- Thus, the NSF funding decisions do not appear to fully reflect the serious adverse impacts, both scientific and political, that withdrawal of U.S. funding would create. This may reflect an institutional problem with respect to NSF funding. Most external grants funded by NSF have a staff to administer them. Not so with IIASA. NSF's financial contributions flow to the Academy and are administered through the Academy. Hence there are no natural "internal protectors" within NSF for IIASA funds.

5. ARGUMENTS AGAINST CONTINUED SUPPORT FOR IIASA AND REBUTTALS

In addition to the NSF budgetary problems motivating towards a possible U.S. withdrawal, it appears that some political arguments have been made by certain National Security Council and Office of Science and Technology Policy staff members. However, these arguments are believed to be of secondary importance with respect to the benefits of continued U.S. participation in IIASA. The arguments are:

- The USSR, by increasing world tensions, has worked against the spirit of detente. The U.S. should show its disfavor by withdrawing from scientific contacts with the USSR.

Counter-argument:

IIASA is one of the places where the Soviets are working cooperatively with the U.S. on common problems. While it is appropriate to respond strongly to Soviet actions where they are against U.S. interests, in cases where the Soviets are demonstrably working constructively with us it is inconsistent to terminate those activities. Furthermore, IIASA is not a bilateral activity: Soviet scholars interact at IIASA with scholars from other Eastern European countries and in these contacts the Soviets do not "dominate" or "control". Several research project leaders are from Poland and Hungary. Indeed, as bilateral links are to be closed, the effective multilateral forum at IIASA, where U.S. scientists continue to have a window into Soviet thinking and to Eastern European communities, gains ever greater importance.

IIASA provides an important vehicle for peaceful U.S.-USSR cooperation, during a period of increased tensions. It is essential, as recently expressed by a number of politicians in Western countries, to keep such lines of communication open.

o The scientific interchange between East and West within IIASA has been stronger in one direction than in the other. The Soviets are interested in IIASA because they can learn from the West. Information transfer is overwhelmingly from West to East.

Counter-argument:

The Soviets have shown a willingness to make strong scientific contributions to the IIASA program. In spite of the definite constraints on recruitment from the USSR (and other NMO countries except the U.S., U.K. and Canada) caused by the use of English as the working language, the quality of scientists from Eastern European countries is now quite as high as that of those from Western countries and the U.S. As well as a USSR Nobel Laureate, IIASA has had either on its staff or participating in shorter term visits or as conference participants a large number of Soviet Academicians and many very outstanding younger colleagues.

Further, because of its collaborative setting, IIASA has managed to get input (both of models and data) from socialist countries which was not available in the West before. For example, the Impact model, which constituted one of the main blocks on which the scenarios of IIASA's global energy study was built, was developed at the Siberian Power Institute at Irkutsk. Data for a case study on environmental and technological consdquences of agricultural production is being made available by Soviet agricultural experts. Large amounts of data about the Silistra Agro-Industrial Complex in Bulgaria were made available for the IIASA study of regional development there.

Thus, the USSR and other socialist countries have contributed both in terms of scientific participation and in terms of access to information. The results of collaborative IIASA studies, in the form of mathematical models, data, and reports, are freely and openly published and available to both East and West.

The "exposure" of Soviet scientists to the open "Western" scientific environment is changing attitudes in a significant way within the Soviet scientific community. Soviet economists are openly discussing merits of mixed economies in, e.g., the Hungarian model, with their Western counterparts. All the researchers who return to the Soviet Union after the IIASA experience bring with them personal experience of the benefits of freedom and openness of Western (academic) society, and the merits of decentralization of decision-making and the effectiveness of incentives.

o The Soviets have utilized IIASA, and particularly the IIASA computer network, to gain access to U.S. data, software, and hardware not otherwise available to them.

Counter-argument:

This issue has been examined in depth, and appears to be lacking in serious substance. With respect to Soviet access to U.S. data sources, the links between IIASA computers and U.S. data bases are limited to commercially available data bases which can be readily accessed irrespective of IIASA by a number of means. At most, the IIASA network can be regarded as a convenient means of Soviet access to U.S. information which is readily obtainable by other commercial and legitimate means. Conversely, the IIASA network provides the U.S. with information from socialist countries not readily available by other means.

With respect to one-way transfer of computer software and hardware, IIASA does not develop software and hardware. IIASA does utilize software systems developed in the U.S., but these systems are openly available in other U.S. and European research institutions. IIASA does not furnish computer hardware to other countries, East or West. On the contrary, IIASA has obtained commercially available hardware from both East and West, for its own operational use.

o The Soviets can use IIASA as a base for intelligence and spying activities. Indeed, a high level administrator at IIASA has been recently forced to resign after allegedly engaging in espionage activities outside of IIASA.

Counter-argument:

This unique case is unfortunate and the U.S. NMO has registered its extreme dissatisfaction. No guarantees can be given that it will not happen again, but every possible effort will be made to prevent this. Occasional "unmasking" of intelligence agents on the staff of U.N. agencies is not infrequent and generally accepted as an "occupational hazard" in international organizations. It is even, perhaps, surprising, that IIASA had been in existence for over eight years before such a case occurred. In contrast to such events at intergovernmental international organizations, the IIASA Director was able to act quickly to obtain the resignation of the person accused, and his action received the full support of all 17 members of the Institute's governing Council (including the Soviet Chairman). Further, IIASA does not provide a unique opportunity for the Soviets to engage in clandestine activities in Vienna. There have been a number of cases in the past at the U.N. agencies in the city.

6. CONSEQUENCES OF U.S. WITHDRAWAL

o The U.S. cannot withdraw from IIASA for a year or so and then resume its membership. U.S. involvement is pivotal, and announcement of U.S. withdrawal would have profound effects.

o One effect would be a modified IIASA, involving Eastern and Western Europe, Canada, Mexico, and possibly others. Discussions at the November 1981 meeting of the IIASA governing Council indicated strong desire for continued U.S. involvement, but also strong sentiment for finding ways to maintain IIASA without U.S. involvement, if necessary. Should this occur, the absence of the U.S. would appear to be counter to its interests.

o Conversely, although this currently seems less likely, withdrawal of U.S. support might result in a chain reaction of reciprocal actions, with other nations withdrawing support, and leading to collapse of the Institute.

o Destruction of IIASA would not simply be a cutback of another program or the reduction in support of a few researchers, it would be the elimination of:

- a *unique institution* that took six years of negotiations by 12 nations and eight years of investment and operation by 17 nations to achieve its current position of high scientific productivity, wide respect, and international trust;

- a *network of over 200 collaborating institutions in more than 20 nations*, built up laboriously, that participate in IIASA's work and rely upon IIASA's linking role to coordinate their efforts to understand international issues;

- a *body of knowledge about and a methodology for international study* of the major issues that concern all nations; the future development of the global energy, agriculture, industrial, and resource systems;

- the *only non-political site for study of international problems* by international teams of scientists and engineers; in particular it is the only place where teams from both West and East (especially the United States and the Soviet Union) cooperate in the examination of these issues;

- a *research organization* that has developed new knowledge and new methods for the interdisciplinary investigation of the complex systems that affect these important problems.

o The political effects of the destruction of IIASA should not be viewed solely in terms of U.S.-USSR relationships. Austria has strongly indicated that such action would be damaging to Austrian prestige and foreign policy. A number of Western European countries and Canada regard IIASA as providing them with significant benefits, and are likely to remain active, but would find U.S. withdrawal in important loss. Mexico is now actively considering membership and/or collaboration, and this also strengthens the importance of continued U.S. involvement.

7. IIASA COUNCIL ACTION, November 16, 1981

The IIASA Council discussed the prospect of U.S. withdrawal at its November 1981 meeting. Council members unanimously stressed the importance of finding ways of keeping the U.S. involved in the Institute, even at a sharply reduced level of funding. The Council unanimously passed a resolution (Attachment) designed to extend the mandatory deadline for withdrawal, and to permit a sharp reduction in U.S. dues. The NAS is now being asked to reconsider its intention to withdraw. NAS, in turn, is expected to propose to the U.S. government that continued funding be provided at a reduced level.

8. SUMMARY

- IIASA has been more successful (both scientifically and diplomatically) than the founders in the U.S. expected. U.S. (as well as other) scientists who have spent time at IIASA overwhelmingly support its continued existence (see Attachment).

- IIASA's present and future potential benefits vastly exceed the costs to the U.S. The U.S. supports only 23 percent of IIASA's operating budget, but has access to 100 percent of IIASA's research. While not all this work is relevant to the U.S., much of it is. In many cases (for example with the global studies), because of the U.S.'s major international role, significantly more relevant. Therefore, U.S. investment has a multiplier effect.

- IIASA has gained respect from both East and West for the diverse activities it now carries out. If the U.S. withdraws its financial support from IIASA it will be construed by U.S. allies in Western Europe and by those countries in Eastern Europe (mainly Poland, Hungary, and Czechoslovakia) that want to maintain and improve their contacts with the West, as a hasty and unwise diplomatic action.

- In addition to its already well demonstrated value in fostering cooperative international science activities, IIASA has the potential for demonstrating an effective U.S. follow-up of Cancun. U.S. support of high quality, objective studies of complex development issues could demonstrate to the developing world a positive concern for addressing long-range questions raised at Cancun.

- Decisions which might lead to collapse of IIASA, with serious scientific and political impacts, appear to have been made largely on the basis of staff level discussions, with only fragmentary policy level input, and possibly with inadequate consideration of the full range of impact. The implications of U.S. withdrawal from IIASA are serious enough to warrant thorough top level discussion and reconsideration.

Mr. Brown. The chairman will return soon. We have another panel of witnesses.

We will call the last panel of witnesses: Dr. William Baumol, Department of Economics, New York University; Dr. Philip Converse, professor of political science, University of Michigan; and Dr. Charles Kiesler, Bingham professor of psychology, Carnegie-Mellon University.

We recognize all you gentlemen as eminent spokesmen in your field. We are very pleased to have you here this afternoon.

Dr. Baumol, I understand you have a time problem. We will do our best to make sure you do not get stranded in Washington, whatever the problems may be.

Dr. Baumol. Thank you very much.

Mr. Brown. You may proceed with your statement, if you wish.

The full text, of course, will be included in the record immediately following your oral presentation.

STATEMENTS OF DR. WILLIAM BAUMOL, DEPARTMENT OF ECONOMICS, NEW YORK UNIVERSITY; DR. PHILIP CONVERSE, PROFESSOR OF POLITICAL SCIENCE, UNIVERSITY OF MICHIGAN; AND DR. CHARLES KIESLER, BINGHAM PROFESSOR OF PSYCHOLOGY, CARNEGIE-MELLON UNIVERSITY

Dr. Baumol. Thank you very much. I certainly am deeply grateful for this opportunity to appear before you to testify on this important subject—the supply of resources for research in the social sciences and the role of the National Science Foundation in this arena.

I may mention informally, on a subject that came up earlier, that in fact the social sciences are deeply involved in the study of the Nation's productivity problems. I can speak from personal experience. I am doing research for a committee on economic development study on productivity, which is going to be discussed before them tomorrow. I have a proposal for further study on the economics of productivity policy before the National Science Foundation on which tentative approval has been granted.

Mr. Brown. Just assure us that you are not doing any more studies for the Japanese.

Dr. Baumol. I have not now, nor have I ever, done any studies for them.

I come before you as past president of the American Economic Association, an organization of 18,000 economists in business, government, colleges, and universities. We are certainly cognizant of the efforts of this subcommittee and of the House of Representatives on behalf of the funding of research in general and in the social sciences in particular.

I am gratified at the mutual support of the entire community of scholars and their emphasis on the vital role of research in all areas—the physical, the biological, and the social sciences.

The atmosphere certainly has cleared considerably since last year when the social sciences were singled out for a devastating 75-percent cut in funding. Happily, that did not materialize, and the current budget for 1982 no longer isolates the social sciences for uniquely harsh treatment. Yet, the crisis is far from being over and cessation of vigilance is premature, as I will mention presently.

Last year's implicit attack on the social sciences is undoubtedly attributable to misunderstanding of their character and contribution, and this merits brief exploration.

The impression seems to have arisen that social scientists are all biased toward the left and unanimously champion big government and subversion of the market mechanism, but this is certainly untrue. My profession includes respected monetarists, supply-siders, and libertarians. Indeed, most economists, even those of the most liberal persuasion, generally are unreconstructed admirers of the free market system.

Social scientists are also victims of excessive expectations, some of which they themselves helped to foster. They have produced no instant cure for crime or drug abuse, no painless cure for inflation. But scientists, too, have similar problems. They have found no foolproof way of disposing of nuclear wastes nor any universal cancer cure. Why should the one be more subject to criticism than the other?

A third source of misunderstanding of basic social science research really besets all basic research. By definition, basic research is research with no immediate object in view. It is not intended to build a better mousetrap or a better recorder of TV programs. Yet, in the long run it is basic research which has yielded the highest payoffs. Abstract number theory has underlain the computer revolution and automation. Research to discover the structure of matter underlies our most promising future energy source, nuclear fusion.

In the social sciences, basic research in the theory of economic interdependence has shown how environmental goals can be achieved with minimal social cost and minimal interference with private enterprise. Even cursory examination of the history of the devastating business fluctuations in the 19th and early 20th centuries contrasts markedly with their history since World War II and shows how far we have come, how much society has benefited from basic research in the social sciences.

The record of the National Science Foundation in all these areas has been exemplary. It has consistently supported research impartially, regardless of the political orientation of the researchers. It has shown no bias by field of research or geographic location of the researcher. It has funded the most promising work, both traditional and innovative. In all this, excellence has been one indispensable criterion.

NSF deserves support in all its arenas, and among them social sciences must not be neglected. In a society beset by inflation, crime, violence, and the threatening productivity slowdown, inadequate devotion of resources to the research on just those subjects can prove a very poor economy indeed.

But, as I have said, this threat still hangs over us, despite the restoration of some funds in the 1982 budget, as we have seen already today. In the 1983 budget funding that for social sciences in the National Science Foundation is 43 percent less than the budget for that division in 1980. Moreover, it should be noted that this figure includes no correction for inflation. That is, in dollars of constant purchasing power, the proposed cut is, of course, considerably larger.

It has been implied that private industry should be looked to for funds no longer supplied by Government, but this is largely a forlorn hope for the funding of basic social science research. The mechanism of the market forces industry to concentrate on applied research rather than on basic research, whose payoff characteristically is unpredictable and whose beneficiaries are generally not known at the time the research is carried out.

But even this avenue is blockaded for social science research much more than in other fields. Particularly noteworthy is the fact that the tax bill of 1982 provided a tax credit for industrial investment in research and development, but what is significant here is that this provision explicitly excluded investment in social science research.

It follows from all this that the struggle for adequate funding is hardly over. There is still a great deal to be done if the United States is to have the resources to retain its preeminence in economics and the other social sciences. This is no matter of study for study's sake. The United States is locked in a life-and-death struggle for its lead in the international marketplace. At stake are our living standards, our quality of life, and our leadership.

The pursuit of these goals is heavily a matter of economics and social science. Can we really afford to proceed without maximal information and insight in an area which holds the key to our future?

It has truly been said that research is costly but that ignorance is incomparably more expensive. Unless the social science budget is not cut nearly in half, unless funding is restored to its 1980 level in terms of purchasing power, the Nation will, in the long run, have ample cause for regret.

Thank you very much.

[The prepared statement of Dr. Baumol follows:]

William J. Baumol
February 23, 1982

Statement before the Subcommittee on Science, Research and Technology, U.S. House of Representatives, NSF Authorization Hearings

My name is William J. Baumol. I am now Professor of Economics at Princeton and New York Universities. I have been President of the American Economic Association, the Eastern Economic Association and the Association of Environmental and Resource Economists.

I am most grateful for the opportunity to appear before you and testify on the important issue of research in the social sciences and the provision of the resources it requires, particularly through the National Science Foundation. You are, of course, beset by claims that particular activities and enterprises are vital for the national interest, and often those claims are well justified. I am here to offer the same assertion about government support for basic research in general, and for research in economics and the other social sciences in particular. For it is clear that at no time in the second half of the twentieth century has the U.S. been more in need of insights and guidance on matters affecting the long run course of its economy and its society. In the long run our leadership is threatened perhaps more profoundly by the economic success of our allies than it is by the military challenges of our opponents. Our society is beset by crime, by disturbances and dislocations which affect all our lives. Surely, this is no time to cut down the flow of resources to those research activities dedicated to providing illumination on such difficult issues. Research may be expensive, but the ignorance preserved by its absence is surely far more costly.

Misapprehensions Underlying Last Year's Budget-Cutting Proposals

Happily, the proposal that support for research in economics and the social sciences through the National Science Foundation be cut by some 75 percent is now a thing of the past. The administration has thought better of this plan and has now called for a reduction in the amount of purchasing power supplied for the purpose that is considerably more modest. Nevertheless, the threat posed by the earlier proposal indicates that the contribution of the social sciences is beset by misperceptions which it is important to clear away. It is therefore important to deal at least briefly with some of the most noteworthy of these misunderstandings. Three of these in particular merit comment: a) the political orientation of social scientists and social science research; b) the excessive expectations they engendered earlier and c) the nature of basic research in the social sciences and its long term payoff.

Political Positions of Social Scientists

Social scientists, like the members of other groups are not political eunuchs. Many of them belong to political parties, hold strong opinions and may even be active in their support of those they favor.

The misconception that has somehow arisen in this area is that social scientists as a group preponderantly take the same side in their political positions. It has come to be felt that they are largely left of center, that they favor big government, and espouse restrictions upon freedom of enterprise.

A dispassionate review of the work of economists shows categorically how groundless this view is. Monetarism and supply-side economics are both the products of the work of academic economists whose conservative political leanings are open and well known. There is a profusion of economists and social scientists whose views are to the right of center and their work has over the years been supported by the National Science Foundation and other government agencies no less generously than that of economists of different political views. It may be added that even less conservative economists have preponderantly favored deregulation, the encouragement of free enterprise, and have been strong in their praise of the accomplishments of the market mechanism.

Excessive Expectations

A second set of misapprehensions which doubtless underlay the proposals for drastic cuts in funds for social science research are ascribable to excessive expectations. Sociologists and psychologists are denigrated for having failed to find the way to put an end to drug addiction and economists are derided when their predictions prove imperfect and when they provide no painless cure for inflation. For no clear reason, these gaps in our knowledge and abilities are taken to constitute failures far more serious than medicine's inability, so far, to provide a definitive and universal cure for cancer, or the engineer's inability to provide completely safe techniques for the disposal of radioactive wastes.

Social scientists themselves are partially at fault here. Their spectacular successes during the Kennedy-Johnson years in the application of macroeconomic analysis encouraged excessive expectations and led even President Nixon to assert that "we are all Keynesians". The world was encouraged to believe that the secret of economic stability had been unlocked, and that a panacea for inflation and unemployment was in our possession. In a world in which these matters depend heavily on developments beyond the control of economic policy -- on wars, crop failures and the formation of international cartels controlling vital raw materials, the search for any such panacea is chimerical and can only lead to public disappointment. To the extent that economists and other social scientists encouraged oversanguine expectations they do bear responsibility for the ensuing distrust of their abilities. Yet such distrust leads us to lose sight of how much they have accomplished and how many problems society is now able to deal with more effectively than earlier generations could. I will cite some examples a bit later.

Basic and Applied Research

A third and perhaps most fundamental source of misunderstanding of the contribution of the social sciences stems from the nature of basic research itself. Basic research, by definition,is research devoted exclusively to additions to knowledge, without any prespecified application in mind. It does not seek to provide a better glue, or a more heat resistant metal, or to solve any of the immediate problems of industry or government. Consequently, in the short run basic research often provides very few payoffs whose value is readily measurable in dollars and cents.

Moreover, because such basic research has no explicit applied objective it lends itself to caricature, and is all too easily held up to ridicule by those who want to emphasize its impracticality.

But the long run payoff to basic research has been enormous. Research in abstract number theory has led to the design of the modern computer and all the associated techniques which underlie the unprecedented rise in economic abundance of the earlier postwar period. Basic research seeking only to provide insights into the structure of physical matter has led to the progress toward fusion which may constitute the most promising approach toward safe and abundant energy in the foreseeable future. It is easy to provide example after example showing how apparently economically purposeless activities by "impractical" researchers has been the source of crucial contributions to American living standards, American leadership and American strength.

Basic research in the social sciences is particularly vulnerable to the taunt of impracticality. To understand the processes by which people act and interact, social scientists must have recourse to abstract models to substitute for experiments on people when those are unthinkable or just excessively costly. They often must proceed by indirection because humans are aware when they are studied and their observed behavior may be affected by that awareness. Yet basic research in this arena is our only hope of providing the information needed to base the design of policy on rigorous analysis rather than hunch and relatively untested judgment. The fact that in the long run basic research alone can provide the major contributions to knowledge which society needs should reconcile us to the fact that it may offer only modest payoffs in the short term. Unless this is understood and generally accepted,a serious impediment will beset the provision of adequate resources for this activity which is so vital for the nation's future.

Past Contributions of Social Science Research

As I have already noted, excessive expectations for macroeconomic analysis have lead to disappointment. But the enormous accomplishments of macroeconomics must not be overlooked as a consequence. If we compare the great fluctuations in employment and GNP which characterized our economic history throughout the nineteenth century and up until World War II with their relative stability in the postwar period, we must be convinced of the very great degree of progress that has occurred. There is little doubt that much of our understanding of the causes of business depression and unemployment and the policy maker's enhanced ability to keep them under control is ascribable to academic research.

Similarly, basic research has provided substantial new insights into the consequences of regulation, the things it can and cannot be expected to accomplish, and the means it can use to achieve its objectives while interfering as little as possible with the workings of private enterprise. The recent process of deregulation of air transportation and of partial deregulation of railroads has benefitted greatly from insights gained through basic research in economics.

The same is true of environmental policy. In this arena academic research has provided the basis for innovative techniques which permit a substantial reduction in the cost to industry and to the economy generally of meeting the environmental standards adopted under congressional authority.

Other examples of the practical yield of basic research are easily provided. But it is equally important merely to indicate areas in which such research is now going on, in order to suggest the benefits it may yield in the future. As is only to be expected, there is a great deal of work now under way on the economics of inflation designed to determine the mechanism by which it is generated, the measures which can be used to restrain it, and the possibilities for reducing the severity of the tradeoff between inflation and unemployment which is perhaps the most serious impediment to acceptable policy in this arena.

A very different area of fundamental research is that related to crime. Sociologists have for some time devoted themselves to the study of this subject, and in recent years a number of economists have turned to it as well. The latter have, for example, begun to examine evidence on the incremental costs and consequences of different crime prevention activities. They have investigated the effects of different divisions of the available funds among such things as the hiring of additional policemen, the purchase of additional police equipment and the construction of additional prison facilities. They have even worked toward determining which such allocation of the available budget can be expected to yield the largest reduction in criminal activity per dollar of outlay.

A third area of current research may prove to make a profound contribution to national well-being in the long run. In recent years productivity growth in the United States has fallen to a small fraction of its former level. Moreover, for several decades U. S. productivity growth has been about half of that of the leading European economies and a third of that of Japan. The analogy with the history of the British economy is disturbingly close, and a little extrapolation makes clear the threat to our nation's economic leadership and its relative standard of living. A number of economists are now devoting themselves to empirical and analytical research on the sources of our productivity problem and the means that can be used to stimulate productivity growth. The problem will obviously not be solved overnight and its consequences will undoubtedly be with us for a considerable time. The issue is clearly critical for our future and it is an area in which it is hardly wise to proceed in ignorance. Surely, inadequate funding of this sort of research can in the long run be very costly.

The Vital Role of Government Funding

Research in the social sciences is far less expensive, in general, than that in the natural sciences, where elaborate equipment, enormous projects and intricate experiments are often essential. Nevertheless, the amounts necessary to permit an effective program of social science research cannot be expected to be provided preponderantly by sources other than the federal government.

There are three other sources from which such work has traditionally drawn some assistance -- from the universities themselves, from private foundations and from industry. But none of these can be expected to provide any substantial part of the requisite resources in the foreseeable future.

The universities, as is well known, face financial difficulties compounded by the end of the baby boom and the persistence of simultaneous inflation and recession. They will have difficulty enough in meeting their own needs and can hardly be expected to provide funding to other groups.

The foundations, too, have suffered major financial reverses. High interest rates and lagging stock prices have depressed the purchasing power of their portfolios. Many of them find their endowments today to be less than half (after correction for inflation) of what they were a decade earlier. It is hardly surprising, consequently, that private foundation grants to the social sciences have fallen, and certainly the foundations cannot be expected to increase substantially the resources they provide to social science research.

Private industry is, of course, one of the nation's prime sponsors of research. However, competitive pressures acting through the market mechanism channel almost all of industry's investment in this area into applied rather than basic research. By its very nature, it is very difficult if not impossible to foresee who will be the ultimate beneficiaries of any particular basic research undertaking. A private firm can hardly be expected to finance an activity whose benefits may well accrue outside its industry or, worse still, may turn out to help its competitors. For these reasons, while U. S. industry has been generous in its funding of applied research, its financing of the nation's basic research, even in the natural sciences, and certainly in the social sciences, has always been comparatively small. The nature of the market forces responsible for this pattern indicate strongly that no significant changes are to be expected here.

In short, if the U. S. is to have the significant program of basic research in the social sciences which its interests require, the funding can come from only one source -- the public sector. Any pretense that significant alternatives are available must be rejected as an exercise in self-delusion.

What is at Stake

The issue now before us is not merely the volume of research that will be carried out next year or the year after that. The decisions on research funds that are taken today have vital implications for this nation's activities in the social sciences for decades to come. As I wrote on another occasion, government funding has played a particularly crucial role in facilitating the work of younger social scientists during the years before they have achieved their full reputation. These are often the years when many make some of their most important contributions.

This is a matter which is particularly crucial now because, as a result of fortuitous events, younger faculty are in a disadvantageous position unparalleled in recent memory. The baby boom that was an aftermath of World War II created an enormous demand for college teachers two decades later, and many faculty members were appointed to meet this unprecedented demand. But as the growth of the student body has declined in recent years, the institutions of higher education, already under severe financial pressure attributable to inflation and other causes, have found themselves overstocked with faculty. Thus, openings for new faculty members have actually declined far more than in proportion to the fall in the size of the student body. In many departments young persons entering the faculty today are told routinely that there is virtually no hope of promotion to a permanent position. If, in addition, research funds are not provided to them, there is a very real danger that economics and the other social sciences will lose the contribution of most of a generation of potentially productive researchers, a loss I believe our country can ill afford.

Today the U. S. is preeminent among the nations of the world in the quality of its research in the social sciences. This is illustrated dramatically by the enviable American record in terms of Nobel Prizes. Of the 19 awards made since the inception of the Nobel Prize in economics, ten have gone to Americans. During the postwar period outstanding students from other countries came in a steady stream to the United States to complete their postgraduate training and to join our research programs before returning to their homelands. Famous social scientists from every free country hope for the opportunity to spend a year in the U. S. so that they can work with their American counterparts.

The National Science Foundation has played a vital role in this history of success. It has been the one consistent source of funding of basic and disinterested research. It continually supports research, some of which has paid off already, and some of whose payoffs will accrue in future decades, and not just the day after tomorrow. Its support has already paid off in terms of practical results and continues to do so. Its help has been extended impartially to investigators of differing political opinions, to younger and older scholars and in every region of the country.

Our preeminence in the social sciences will be threatened for decades to come if insufficient research funds are now provided. But even more is at stake. As I have already noted, our society and our economy are beset by many critical problems threatening our welfare and our nation's leadership in the short run and in the long. We cannot afford to act upon them without analysis and without information. It is surely essential that those who can provide the required ideas and insights be given the resources needed for the purpose. To do less is to shortchange our futures.

Mr. **Walgren**. Thank you. I understand that you have a plane to catch. In the interest of that, I would like to recognize Mr. Brown.

Mr. **Brown**. Dr. Baumol, let me ask a question or two. Then I guess we can excuse you.

You were probably here earlier at the testimony from the representatives of the Foundation with regard to their attitudes toward the social science program, which I perceived at least as being constructive. I would like to get your reaction to it other than the comment that you have made about the level of funding, which is understandably disappointing.

With regard to the general approach that they have enunciated, do you feel that this will help to improve the quality and respectability of social science research?

Dr. **Baumol**. Oh, yes, undoubtedly. However, there is a danger in that, too.

Let me say that I have dealt with the leadership of the National Science Foundation before, and they have never been parochial in favoring any one particular field over another. This I have always admired and respected.

However, it is precisely because of this attitude and the change in attitude of the administration that people generally feel that the crisis is over. It is very much this admirable attitude which I think has led to relaxation of efforts, and which is likely to make the social sciences much more vulnerable to nothing being done about the proposed budget cut than they were last year when they felt beleaguered and unfairly singled out.

Mr. **Brown**. Of course, I think our effort here in this committee is to assist in achieving what Dr. Slaughter referred to as a balanced budget in this respect. I would give credit to the Foundation in its efforts for I think trying to defend themselves against the attacks that have been made on the social science programs, and perhaps even to prepare the ground for further advances in these areas in a strong way. I would hope that is the case, at least.

If we can weather this present situation, we may be in a position then to reemphasize the really very substantial contributions of the social sciences to the very specific problems that face our society and our economy today. I do not know that there is any magic route to achieving this, but I at least do not feel that we have been completely routed and are in disarray quite as much at the present time.

Dr. **BAUMOL**. I agree with you strongly. I am aware of the work of this committee, of course, and recognize the validity of what you have said. I also do not in any way want to denegrate the attitude of the National Science Foundation. It was our own relaxation of efforts that I was displeased with, not anything that the National Science Foundation had done.

Mr. **BROWN**. One of the sermons that I make to both physical and social scientists is that they can never afford to relax.

Dr. **BAUMOL**. I agree, sir, completely.

Mr. **WALGREN**. Thank you, Mr. Brown.

Mr. Lundine?

Mr. **LUNDINE**. I would like to address one question.

It strikes me that in an era when economics seems to be being proven more of an art than a science we may be struggling here in this whole social science area with some important, difficult problems of relevancy. I can appreciate what you said about basic research and the need for sponsorship of those things that are not as likely to get support elsewhere because the short-term payoff does not seem to be as great.

However, I just wonder about the whole model. It seems as though you have taken mechanisms that essentially were designed for physical sciences—or NSF has, and I do not mean that in an accusatory sense. NSF has taken models that were devised for physical sciences and applied them to your kind of work.

I wonder if there would be more validity in more action research, more participatory sort of methods to be used. I wonder if you have any comment on that possibility.

Dr. **BAUMOL**. Yes, sir. I have several comments, if I may.

First, of course, you are right that there is no philosopher's stone—no one method that is going to reveal truth in so complex an arena, and that participatory methods, more experimental methods, methods involving direct observation rather than theoretical models, are going to have and/or are already having high payoff.

Of course, in the social sciences there are special difficulties. For one thing, in the physical sciences the very fact that something is studied does not change the behavior of the object being studied. In economics or in the social sciences, the very fact that someone is in an experiment changes that person's behavior.

There are other such complexities—simply the fact that one does not experiment casually on human beings because they are human beings. All of these things mean that sometimes one has to use models where in a magic world we would prefer experiments.

There is one other point, if I may. I want to emphasize that economics is an art when it comes to application, not when it comes to basic research. This is true to a great extent even in the hard sciences such as physics. A great physicist once said to me, "I think you will agree that I know the laws of mechanics as well as anyone. Yet, if you look at that hill across the street, put an automobile on top of it and release the brakes and ask me to predict the trajectory, I couldn't begin to do so."

I have had engineers say to me, "Do you know how we build bridges? We calculate what strength is required for the cables. Then we arbitrarily treble them—and bridges still fall down."

The fact is there is a difference between the theory and the application. We are asked to go from what is in effect the laboratory, from the simplified state in which we can predict what difference a change in interest rate makes when all other things are held constant, and then enter the world where things are not held constant, where we cannot tell what Mr. Khomeini is going to do next or what Mr. Brezhnev or someone else, which throws all predictions into a cocked hat. However, that is quite different from saying that what we have learned in the laboratory is not science.

Mr. **Brown**. Would the gentleman yield to me?

Mr. **Lundine**. Certainly.

Mr. **Brown**. This is not really significant, but you have made one statement which I think needs to be at least modified. That is that in the physical sciences things are not changed by the process of observation. They are changed.

Dr. **Baumol**. Sorry. I was thinking as I spoke that I should say something about the Heisenberg principle.

Mr. **Lundine**. To get away from such detailed principles, you made the observation about the tax credit. Would you support the idea of extending that tax credit to include social science research?

Dr. **Baumol**. I think that is right. To the extent that social science research can contribute to productivity and can make a difference in the effectiveness with which we use our resources, it is something which is in the Nation's interest and the interest of industry. Unless one believes that social sciences are powerless to make that sort of contribution, then it is certainly imperative.

Mr. **Lundine**. That is not within the jurisdiction of this committee. I hesitate to get into it further.

It strikes me as odd that we are so afraid that we are going to have some giveaway in the social science area. Here, for example, is a case where, albeit, you give them a 25-percent investigation tax credit, the corporation still has to come up with 75 percent of the money. I doubt if they are going to do if they think it is some kind of worthless research. It troubles me. I just wondered what your reaction was.

Dr. **Baumol**. I agree. The fact is that industry does use the social sciences. My phone rings all the time with people from industry asking me to come and give some advice. They may be foolish and they may be mistaken, but at least by their telephone calls they demonstrate that they do not consider economic advice to be worthless.

I suspect you would find that, if they were asked to pay the 75 percent of that social science research, many firms would find it in their interest to do so.

Mr. **Lundine**. Thank you. I hope we have not asked so many questions that you will miss your plane.

Dr. **Baumol**. Thank you.

Mr. **Walgren**. Thank you very much, Mr. Lundine.

I just want to ask on these numbers that are being suggested for 1983, can they be tied in any way to Dr. Slaughter's observation that they are trying to get back to objectivity?

When you look at these reductions of 52 percent in the social and developmental psychology area and 19 percent in linguistics and the like, does that match at all with the description of the method that was being used to arrive at these dollar amounts?

Dr. **Baumol**. I find it difficult to account for those figures, I must admit. I have no obvious explanation for them.

Mr. **Walgren**. Thank you very much. On behalf of the committee, we want to express our appreciation. I think you have plenty of time, so do not run through airports.

Dr. **Baumol**. Thank you very, very much.

Mr. **Walgren**. Then, with that, if a prerogative of a Pittsburgher is to keep a fellow citizen last, perhaps we should proceed first with Dr. Converse and then Dr. Kiesler.

Dr. Converse?

Dr. **Converse**. Thank you, Mr. Chairman and committee members.

I am currently program director of the Center for Political Studies at the University of Michigan and a member of the National Academy of Sciences. One hat that I wear at home involves me with the Inter-University Consortium, a large computer network linking universities and governmental users of social science data. I get a certain perspective on the use of social science materials from that role, which I will address in a few minutes.

As we confronted a year ago the cuts that headed for 70 percent, you heard a lot of testimony about recent contributions of social science, and I am not going to try to duplicate that kind of testimony here. I want to try to give you a sense of what has happened since, and particularly to talk about some of these numbers that have been floating around.

As you know, the social sciences did not suffer that 70-percent cut but only a 50-percent cut. I think many of us in the social science community have a sense that it is this committee which mainly stemmed that tide and spared us the deeper cuts of 70 percent.

You had some moral support in this effort from the broader scientific community, including a resolution out of the National Academy, several friendly statements from the National Science Board, and more recently, suggestions from the scientific end of the administration that those cuts were poor judgment. However, I do not think the cuts would have been held at anything like 50 percent but for this committee. At least, that is my reading.

I say thank you because now I am going to sound ungrateful and, with Mr. Brown, I am going to not relax yet.

When we look at the real numbers as they are now proposed for fiscal 1983, it is very clear that if you keep in mind the original levels of social science funding—by that I mean the levels in 1980—that taking account of inflation, and taking account of problems of economies in scale in running those programs, those cuts are in real dollars tending more to 70 percent by now than to 50 percent.

I would like to give you some sense of how in recent years social science programs in NSF have had a major impact on social science which goes beyond the dollars involved. Obviously the dollars are crucial, but the influence has gone beyond the dollars involved.

The NSF social science programs have served to my mind to draw progressively the mainstream of social science away from loose speculation, away from social advocacies in the direction of true basic science—by which I mean the confrontation of verifiable theories with hard empirical data designed specifically to address them. The National Science Foundation has accomplished this push toward real science in several ways.

I am going to try to illustrate what I have to say with one fraction of their total portfolio. Dr. Slaughter was referring to the emphasis placed on large data bases, one of the three emphases which he laid out. I would like to talk a little about that, in part to give you some sense of what is going to happen at these lower funding levels where these large data bases are concerned.

The NSF support in this quadrant goes to the updating of large-scale longitudinal data bases which accumulate as monitorings of the American population in a number of domains, such as family income dynamics, aspects of the quality of American life, electoral behavior, time use in the population, and the like.

These data bases have become very central to basic research in social science in recent years, in part because scholars interested in the dynamics of complex societal processes have come to understand they cannot get far without information of this kind, any more than a Renaissance astronomer could hope to say much about planetary motion on the basis of one, two, or three points of observation.

Now, of course, you do not create data resources of this sort overnight. You have to wait for them to accumulate over the time as you monitor the population. Even the longest of these series is only about 30 years old.

However, there are several such series which are growing. They already are paying rich dividends. Their intrinsic value rises rapidly as the series lengthens.

These data collections have to be launched from single institutional bases, typically a university. However, obviously they do not deserve public support if they are private preserves of particular investigators or single institutions.

Here I think the scientific leadership from NSF in general, and the SES Division in particular, has been superb, working from the model of national resource or the national laboratories as developed elsewhere in the Foundation.

This means that these large data bases are collectively designed by scholars from all over the country. By encouraging the proper dissemination mechanisms, in which once again the Foundation has been very helpful, open access to the data is made a reality, not some legal fiction.

Now the consortium which I mentioned at the outset is one of those dissemination mechanisms. It is supported not by the Foundation, but rather by subscription of well over 200 colleges and universities here and abroad who receive, in return, routinized access to its large archive of social science data holdings.

Within that archive as we monitor the use rates of social science information, as we can do easily there, the heaviest target of use these days are these growing longitudinal data bases that have recently been given key help from the Foundation.

As a representative example, data tapes for one leg of such series had been requested by 99 universities within 18 months of the time of its release. I will not go through many of these use statistics, but I have a number here.

That is clearly basic research use. Another whole stream of use which we see at the consortium involves data requests from governmental agencies, apparently for planning and for policy formulation. There are requests from State and local agencies all over the country as well as from most Federal agencies. The list of Federal agencies that have requested data from us over the years is very imposing. It covers all corners of official Washington. It might interest you that the heaviest single Federal user is the Congressional Research Service.

Of course, agencies use these growing longitudinal data bases in a rather different way from basic research. For basic research, the longer the series, the better. However, when an agency such as the Congressional Research Service comes to us, the question is how fresh the data are. If the data are more than a year or two old, then interest begins to fade. However, we are pleased that this basic social science data can do double duty of this sort. It has great basic interest, but it is not without its applied uses as well.

What do these longitudinal data bases cost to update? I can make those figures look huge or I can make them look tiny. Compared to the current population survey or certainly one decennial census, you could wrap a number of those data bases together and they would cost an absolute pittance. Or, again, compared to large data generation installations in the natural sciences, the sums involved are simply trifling. However, relative to the social science budgets, these data bases are frighteningly expensive.

Even a couple years ago with SES Division budgets at the Foundation in the low $30 millions, the six or so series of the most demonstrated scientific merit could not all be completely supported at that overall funding level for the Division. Obviously, these series are not taking up all of that amount; they are taking up something on the order of a quarter of that amount. The problem is, of course, that the Division has other types of important scientific responsibilities as well.

However, with this current budget proposal—and I am looking at fiscal 1983—in the $18 million range, there is obviously no hope for any full continuation of these data bases. Some must be suspended in one way or another.

I say "suspended" and not "terminated" because it is hard for me to imagine they would not be resumed in due time. This is true not only because of the strong thrust of scientific interest now behind them, but also because, interestingly enough, emulations of most of those series are under way in most of the key industrialized nations abroad. I would be astonished if in the long run the

United States were the only Nation unable to afford to monitor its social and economic processes in this way.

Obviously, a suspension of those data series is going to mean a gap; it is going to mean a Dark Ages. This creates technical problems for analysis that are pretty horrifying, but I think the substantive problems are worse yet.

There has for example been great scholarly frustration that the longer series don't shade back into the 1930's. The great frustration arises because the 1930's saw a great economic crisis touch off a dramatic reorientation of national policy. This frustration has been keen enough that some scholars have wasted time trying to reconstruct, in awkward ways, what the 1930's data in terms of these series might have looked like. It is a waste of time, I assure you.

Now, 50 years later, here we are involved in another great economic crisis which we are trying to address with a dramatic reorientation of national policy. With these measurement engines in place, however, we are told that for a while we should stop using them until things get better.

The tragedy is, of course, this: From the point of view of basic research, it is exactly the gravity of our current problems that make the maintenance of these measurements so urgent. Yet it is clear with the proposed funding levels for fiscal 1983 they will suffer grievously.

In closing, let me stress that I have devoted my time, as you can recognize, to a limited fraction of the work supported even by the social science programs in the Foundation. For more conventional investigated-initiated awards, for self-contained pieces of research, it is easy enough to observe that with budgets cut in half you are going to grant roughly half as many awards. However, that statement does not really convey what is lost thereby. It seemed to me perhaps easier to give you some sense of what threatens to be lost by turning to these large data bases. Nonetheless, from my point of view, the conventional grants remain the venture capital, the core of the social science programs.

In sum, then, I am left to plead for a significant restoration toward earlier levels of funding support. To my mind, a generation of evolution in the social sciences toward serious science hangs very much in the balance.

Thank you.

[The prepared statement of Dr. Converse follows:]

Statement of
Dr. Philip E. Converse
before the
Subcommittee on Science, Research and Technology
of the Committee on Science and Technology
U. S. House of Representatives
February 23, 1982

Members of Congress. My name is Philip Converse. I am currently Program Director of the Center for Political Studies at the University of Michigan, and an elected member of the National Academy of Sciences. One of the hats I wear which will inform my testimony today is as an Associate Director of the Inter-University Consortium for Political and Social Research. The Consortium is the major national supplier of computer-borne basic social science research data of the kind in which the National Science Foundation, due to the wisdom of its Social and Economic Sciences Division, has invested heavily in the past decade. Watching demands on Consortium data over time gives me some sense as to the national utility of that kind of information: who needs what kind of basic social science information, when and where. More of that later.

A year this season ago, a group of social scientists appeared before you under the shocking news that federal support of the behavioral sciences within the National Science Foundation alone was about to be cut by some 70% in nominal dollars. They were at pains to point out how basic social science research, supported most notably by the National Science Foundation, had made major contributions to pressing topics ranging from such concerns as national health and economic productivity. These were contributions that seemed ample repayment for the tiny federal investment in such research, which has never arrived at so much as four cents on the federal R. & D. dollar, and which for most of the past three decades has been closer to one cent on the dollar.

I do not intend to duplicate the thrust of that extended testimony. My subject instead is what has happened since, and what difference it has made.

What has happened since is this. The social science budget did not suffer a 70% cut. It only suffered something like a 50% cut, while most of the rest of the Foundation was given leave to try to keep up with inflation. It is no secret in the social science community that we were spared the more severe ravages of 70% cuts primarily because of the wisdom and efforts of this Subcommittee. You had some moral support flowing in from the broader science community, ranging from a rather ringing condemnation of the social science cuts passed as a resolution by the National Academy of Sciences, on through friendly statements at several points from the National Science Board, and on to later statements from the more scientifically sophisticated ends of the Administration to the effect that these social science cuts were in fact poor judgment. But without the vigorous action from this Subcommittee, these concerted expressions of support would have amounted to little more than condolences. The community is deeply grateful.

I wanted to underscore our appreciation at the outset because much of the rest of what I have to say might otherwise risk seeming ungrateful. But the fact of the matter is that where basic social science research is concerned, and despite your efforts of last year and many expressions of support from prized quarters, when we get back to real numbers and bottom lines, we know we are looking at a glass which is half empty. And we know that it is half empty, rather than half full, because we have just witnessed it being half emptied.

What is more, the selective reductions are continuing. While recommendations for the Foundation's overall budget in FY 1983 stand at a 7.7% increase, a figure which may at least keep real dollars constant, programs involving basic research in the several social sciences are being recommended for a 1.1% increase, which if accepted would mean further cuts in real dollars. Indeed, if there are any significant economies of scale in getting research dollars actually out the door, which are lost when programs are cut in half, and if we take proper account of progressive inflation in the interim, then I suspect that the recommendations for FY 1983 look more like a 70% cut in real research dollars for basic social science, relative to 1980 levels, than they do like a mere 50%.

Social scientists are as keenly aware as anyone of the urgency of restricting federal deficits. Given the reasonable premium that this Administration seems to place on maintenance of basic research despite hard times, if the social science cuts were even vaguely proportional, I think you would be hearing very little from us. But of course they are wildly disproportional. Their sheer magnitude means that the basic nature of the social sciences in this country is on the brink of fundamental change, a change which seems clearly retrograde. I should like to spend the remainder of my time suggesting more concretely the lines this change is likely to take.

I do not know whether the Subcommittee fully appreciates the enormous impact that the social science programs in the National Science Foundation have had on the several social science disciplines in this country in the past twenty or thirty years, despite the tiny fraction of Foundation resources committed in this direction. I am not talking merely about dollars dispensed, although they are obviously important. I am talking more broadly about an interaction between the Foundation and serious social scientists which has progressively drawn the mainstream of social science away from loose speculation and various social advocacies, in the direction of true basic science, by which I mean the confrontation of verifiable theories of social and economic process with hard empirical data collected specifically to illuminate them. The role of the social science divisions and their policies in this regard have had many manifestations, at least some of which I should like to point out as I proceed.

By way of illustration, let me talk more concretely about one kind of support given to the development of serious social science by the Social and Economic Sciences Division in recent years, which is in fact only a fraction of the Division's portfolio, but nonetheless a significant fraction of it. These are basic research funds invested in the development and maintenance of large-scale longitudinal data bases which accumulate as monitorings of the American population in a number of domains involving such topics as family income dynamics, aspects of the quality of American life, electoral behavior, time use in the population, and the like.

These data bases may be seen in any of several lights. They are in one sense extensions of the Census by other means, since they expand into areas of research interest that no single Census, or for that matter, the Census Bureau's secondary data collections could ever expect to cover. Needless to say, they differ widely from the Census in many respects. For example, they are not designed primarily for administrative bookkeeping, as is true of many governmental data collections; instead, both the study designs and the variables monitored are in the service of evolving basic theory in the substantive areas at stake.

A hunger for cross-time data bases of this sort began to develop across the social sciences in the 1960s. This hunger grew in part because of envy at the progress made by some areas of economics and specialties like population demography that had in fact been able to profit from long time series of data collected for administrative purposes by governments. It grew in part because of a recognition that scholars interested in the dynamics of complex societal processes could not get far without information of this kind: to expect them to do so was roughly like asking the Renaissance astronomer to infer the key regularities of planetary motion on the basis of observations of their positions at three points in time.

Of course one does not create data resources of this longitudinal kind overnight: one simply has to wait and let them accumulate. Even the longer of these data bases scarcely run as long as 30 years, with perhaps 15 points of observation. But they are growing, are already paying rich dividends, and their intrinsic scientific value as a set goes up very rapidly as they lengthen.

I should not leave you with the impression that the social sciences within the National Science Foundation have in any general way initiated these series, or for that matter have typically paid for the early stages of their development. All have been launched at the initiative of principal investigators in private universities, and very often on the basis of seed money from private foundations willing to risk support for a stage or two. But the NSF has begun to be concerned about their maintenance once their scientific merit, along with burgeoning interest in the given series on the part of a substantial community of basic researchers, has become clearly established.

One of the great attractions of these data bases is indeed that they are in a real way "reusable." And in fact they are being subjected to remarkable and growing usage rates in the relevant research communities. It is at points like this that the scientific leadership of what is now the SES Division in the Foundation has been most helpful. While it is necessary for these data collections to be launched from some institutional base---almost invariably a university---it is obvious that they cannot be supported as the private fiefdoms of a single investigator or institution. In this regard, the model of the national resource or the national laboratory, already well developed elsewhere in the Foundation, has been most helpful. The design and content of the studies composing any given series is under the control of groups of relevant scholars from around the nation. At the other end of the process, access to the data generated is as open as possible, and the Foundation has been most helpful in encouraging dissemination mechanisms which make open access a reality, rather than a legal fiction.

One of these dissemination mechanisms is the Inter-University Consortium, which I mentioned at the beginning of my remarks. This is a subscription organization of more than 200 colleges and universities, some of them abroad, all of whom are willing to pay annual fees for rapid and routinized access to the computer-based holdings. Being a subscription organization, the Foundation makes no regularized contributions to the Consortium. However, it has encouraged its development and has at several crucial points assisted it in upgrading its computer capabilities, the better to serve its clientele.

The Consortium archive handles a large range of machine-readable social science data. Many of these data sets were generated without any NSF connection whatever---indeed some of them antedate the creation of the Foundation. However, the longitudinal data bases given key help in recent years by the Foundation are there, and they are clearly the object of the heaviest use for basic social science research in the current period. For example, I find that the data tapes for a recent leg of one of these series had been requested by 99 universities within the first 18 months after its release, and such a figure is not at all unrepresentative. Similarly, attempts to monitor basic research product from one of these series, while certainly an undercount, showed that within a period of roughly five years some 50 books, 150 journal articles and many more doctoral dissertations were described by their authors as heavily or totally dependent on the National Election Study series alone.

Furthermore, it is worth keeping in mind that this class of use within universities for basic research is only one of which we become aware at the Consortium. There is also a heavy rate of use of these data archives by governmental agencies, apparently for planning and policy formulation: social science data applied to current national needs. Rates of use by agencies of the states and local governments around the country are in themselves rather surprising. But a list of federal agencies requesting data tapes at least at one time or another runs into the scores and represents every corner of official Washington.

In this regard, it might interest you that among all federal agencies, the heaviest single user by some margin is the Congressional Research Service. Once again, I should remind you that the total holdings that are being tapped include a lot of data for which the social sciences at NSF can claim no immediate sponsorship. On the other hand, it remains true that the large longitudinal data bases are very central targets in these governmental requests as well. And it is also true that a considerable vote of thanks is due the social sciences at NSF that this information is as rapidly accessible to government agencies as it is, for they have helped keep the Consortium at the most cost-efficient state of the art in information processing and dissemination. Indeed, it is my clear impression that some users like the Congressional Research Service come to us even for bodies of data generated by other federal agencies, because we can provide them less expensively.

It goes without saying that use by governmental agencies of our growing longitudinal data bases is quite different from their use by the basic research scholar. That scholar delights in the length of the time series involved: it is crucial to his long-range inferences about internal processes at work. On the other hand, when the Congressional Research Service comes to us for data, one of the most immediate concerns is their freshness: if they were collected more than a year or two earlier, then interest fades pretty rapidly. There is surely nothing wrong with these two very disparate ways of using these data bases. Quite to the contrary, we take great pleasure in the fact that they are useful both ways. In the timeworn arguments for basic research it is assumed that one earth-shaking hit and four other useful if plodding discoveries will more than pay for another fifty or a hundred dead ends encountered. But if any investment at all seems to have a current use, whatever the basic research outcome, as seems true of these large data bases, it certainly is no argument against proceeding with them.

With all this said, let us return to the question of what these half-dozen or so major longitudinal data bases cost to maintain and update. It is not hard to make the figures seem laughably small, or prohibitively expensive, according to the frame of reference chosen. Compared to a Current Population Survey, and certainly to a decennial Census, it is true that even several of them wrapped together cost an absolute pittance. Or again, by comparison with the costs involved in the maintenance of any large data-generation installations in the natural sciences, the costs for these data bases are simply trifling.

Relative to the budgets available for social science research, however, these data bases are frighteningly expensive. As of a couple of years ago, when it had become apparent that there were perhaps as many as a half-dozen of these continuing data collections of sufficient demonstrated scientific merit to be of interest to the Division, it was not clear how budgets in the low $30-millions could do the job, because these data bases were only a fraction of the portfolio: the Division had a number of other costly and scientifically important responsibilities. With budgets now cut in half, there is naturally some consternation as to what happens next, where these data bases are concerned.

Under the current budget proposals in the $18-million range for the Division there is no hope of any full continuation of these data bases. At least some must simply be suspended in one degree or another. I say "suspended" and not terminated, because I find it hard to imagine that if these data collections were to be stopped, they would not be resumed in due time. I am convinced of this not only because of the strong thrusts of scientific interest that now lies behind them, but also because emulations and sometimes the most direct copies of several such series are now underway in most of the key industrialized nations abroad. It would seem astonishing to me if in any very long run the United States is the only industrialized nation which cannot afford to monitor its social and economic processes in these ways.

Obviously, a suspension will mean a hiatus, a Dark Ages in an otherwise coherent time series of observations. Now there are technical reasons to wring hands at that, but I think the substantive reasons are easier to convey and perhaps more appalling. For some of the lengthier series which stretch back thirty years, there has always been a sense of frustration that the measurements did not get back into the 1930s, to the point where a great economic crisis touched off a dramatic reorientation of national policy. In at least a few cases, the belief that these missing numbers from the 1930s are crucial to our understanding of social and political change has been strong enough that scholars have labored through painful and not very convincing reconstructions as to what they must have looked like.

Now fifty years later we are involved in another great economic crisis with which we are trying to cope by a dramatic reorientation of national policy. And with several of these measurement engines nicely in place, we are told that for a while now we should stop using them, until things get better. I understand well why the counsel for economic restraint arises, but in these cases it tends to miss the point. It is exactly the gravity of our current national problems which makes the maintenance of these measurements so urgent. Yet it is clear that they are about to suffer grievously without some major restorations in these social science budgets.

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I cannot close without re-emphasizing one fact. While I have dedicated my time today to Division support for these longitudinal data bases, they are of course only a limited part of what the Division has been up to in recent years, and to my mind quite properly so. Indeed, I have seen sketchy figures implying that if there were restoration of social science budgets to earlier levels, the dollars out the door for these data bases and a fair amount of related data-resource activity would only amount to about a quarter of the SES Division budget.

For the more conventional awards to investigators for single and self-contained pieces of basic research, it is easy enough to observe that with budgets cut in half, something like half as many grants can be awarded as well. The problem is that such a statement conveys very little of what is lost thereby, whereas it is easy to make some of the opportunity costs vivid where the longitudinal data bases are concerned. Nonetheless, the conventional grants remain the venture capital, the core of the program both for the Social and Economic Sciences Division, as well as for the cognitive science program within its separate Division.

The halving of their respective budgets is emasculating those portions of the social science portfolio within the Foundation equally, and however much I may prize the data base development, I would not want it to come at the cost of further gutting of the conventional programs.

In sum, then, I am left to plead for a significant restoration toward earlier levels of funding support. A generation of evolution of the social sciences toward serious science hangs, as it seems to me, very much in the balance.

Thank you for your attention.

Mr. WALGREN. Thank you very much, Dr. Converse.

Dr. Kiesler?

Dr. KIESLER. Thank you very much, Mr. Chairman and members of the committee.

My name is Charles Kiesler. I am head of the Department of Psychology at Carnegie-Mellon University. I am Bingham Professor of Psychology and acting dean of the College of Humanities & Social Sciences.

Until recently, I was executive officer of the American Psychological Association, the Nation's largest pscyhological association representing over 65,000 members and affiliates.

My interest and involvement with the NSF goes back a long way. I have been director or principal investigator of six grants from NSF. I served on the NSF Advisory Panel when it covered sociology and social psychology, and then when it was social psychology, the one that is now social psychology and developmental psychology. Within the last year, I served on a panel drafting a report on the contributions of the social sciences to innovations and productivity, which we drafted for inclusion in the President's annual report to the Congress on science and technology.

I also participated in the oversight panel which reviewed the 13 separate reports for the NSF annual report on science and technology. More recently, I participated in a panel advising NSF—a tragic task—how to implement the cuts that have already come in the social and behavioral sciences.

I should note that my own personal research interests have changed over the years, such that they are not fundable from NSF under their mandate. I do not receive any research funds from them now. I do not anticipate applying for any in the near future. I, therefore, am not here to represent myself, but to represent the concerns of the larger community in the social and behavioral sciences.

On behalf of that community, I do want to thank, as Dr. Converse did, this committee, and particularly its chairman, for the efforts last year in attempting to reverse the 75-percent budget cuts in the social and behavioral sciences at NSF.

This committee was the first legislative body to call for restoration of these funds. You authorized an additional $26 million for these disciplines to bring them up to 1981 levels. We are deeply grateful not only for that effort, but for the understanding that it shows for the goals of behavioral sciences.

Eventually, as a result, as you know more than anyone else, of your efforts, $11 million was restored. We are grateful for this. I am here to point out that this still represents a 40-percent cut in the social and behavioral sciences.

We ask that the social and behavioral sciences receive as active support and backing for 1983 as they did for fiscal 1982. My reading of the 1983 budget is that there are very small increases from 1982 to 1983. The program in memory and cognitive processes is slated for a $100,000 increase; social and developmental psychology, $100,000; linguistics, $100,000; and anthropology, $100,000. Political science and sociology are slated for no increase. Although a small amount of money is involved across these programs, the increases do not nearly make up for the past reductions.

A recent review committee of the National Academy of Sciences, which was chaired by my colleague at CMU, Herbert Simon, showed that before the cuts funding in the basic social and behavioral sciences was extremely tight at NSF and elsewhere. The proportion of grant proposals actually funded in NSF and the size of the grants actually funded was much smaller in the social sciences than in other sciences.

For example, in my own field of social psychology the proportion of grants proposed that were funded prior to these cuts was one in six, the smallest proportion in the National Science Foundation. Indeed, if my recall is correct, in fiscal year 1981 the support for the social and developmental psychology program was smaller than when I was on that panel 10 years earlier and it funded only social psychology. These are in advance of the cuts.

Further, the NSF budget and its commitment to social and behavioral sciences cannot be considered in isolation. In fiscal 1981, 60 percent of the basic research in social psychology was funded by NSF. In fiscal 1982, this percentage will rise to 85 percent, in spite of the cuts, primarily because of reductions in research funding and funding priorities in the Alcohol, Drug Abuse, and Mental Health Institute and other places. A smaller amount of money is funding a greater proportion of the basic research.

It is very critical to the future of our country that we maintain a continuing commitment to the accumulation of basic knowledge in the social and behavioral sciences. These are the sciences that study human behavior and thought, and there is hardly a single national problem the solutions to which do not demand some understanding of human nature.

Dr. Slaughter in his testimony before you last March emphasized just this—in a rapidly increasing technological country and society, the knowledge of human nature involved in implementing that technology is absolutely critical. It is generally unknown the degree to which the basic social-psychological research and behavioral research is used now in industry, social institutions, and in management sciences. This is a critical point that I want to come back to repeatedly. The point is that the basic research in the past has paid off. It is now being used. We can calculate the payoff.

For example, the notion of personnel selection and assessment is integral to the way that we conduct business. Both the general approach of this and the details of these procedures are dependent upon basic research that goes back to World War I in selecting officers, to personality testing that was developed in the Veterans' Administration, and through decades of achievement and ability testing in American school systems.

Today, we routinely employ survey research methodology in studies of the American economy; studies that businesses use to make critical investment decisions, that Government uses to predict future revenues and reaction to alternative strategies in policy, and that innovators use to assess the market potential for new products. This methodology rests on accumulative scientific efforts that go back to the twenties, both in studying attitude measurement and statistical sampling techniques.

Human factors research is routinely employed in American business and across the world. Examples are numerous, ranging from the layout of control rooms in nuclear reactors, the design of flight panels in airplanes, and a large number of studies specific to particular problems on actual shop floors. Such studies contribute to human safety, to productivity, and to innovation.

Social and behavioral sciences have contributed directly to the management of the research and development process in other sciences. Existing literature is directly related to the composition of research teams, the organizational structure of research organizations, and the relationship of R. & D. to other functions of a business, such as marketing. In many of the more innovative and productive firms in the United States, this sort of knowledge is used routinely to guide the research processes in other sciences, and often with very direct increases in research productivity.

The management structure and processes of American industry are often based on straightforward behavioral science research. This research would include studies of the relationship of morale and employee satisfaction to productivity, the effects of employee participation in decisionmaking on productivity, the nature of resistance to change of management practices, employee profit-sharing plans, and the relationship of styles of leadership to group productivity.

Anyone who takes an MBA these days is taking courses in just those sorts of sequences. They are all related to basic research that has been done years and years ago.

The potential of the behavioral sciences to contribute to the country's adjustment to rapidly changing technologies is also an area of great potential. For example, consider the interplay of technology and human behavior. Some of my colleagues have investigated the use of energy. The development of energy sources and refinement of techniques of production of energy are clearly problems for the engineering and physical sciences. However, the patterns of use of energy are almost entirely a question of human attitudes and behavior.

Here conservation rests on such simple behaviors as turning a switch on or off; monitoring one's own behavior, as in the use of dishwashers or driving habits; turning up the thermostat in the summer and turning it down in the winter; and acceptance and/or purchase of alternative modes of supplies, such as solar energy.

The behaviors and attitudes invovled are simple and relevant questions easily researchable, and all could have an important impact on the overall use of energy and the patterns of use. I have suggested elsewhere that the Nation's use of energy could be decreased somewhere on the order of 20 to 30 percent simply through well-researched behavioral techniques.

Another example of this interplay between human behavior and technology is the issue of medical compliance. This refers to the behavior of medical patients and the degree to which they will follow drug regimens and other prescribed behaviors. The cost of medical noncompliance is now estimated to be $30 billion a year in the United States alone, but behavioral compliance is an area that has been researched in the United States for 30 to 40 years. The basic research and theory are there. Only the intermediate research that connects the basic research with specific solutions needs to be done.

Health economists and a variety of others have suggested that the next major step in improving the Nation's health is not a medical step, but a behavioral one. The Surgeon General's recent report "Healthy People" examines the 10 leading causes of death in the United States and concludes that 7 of these in large part are behavioral, not medical. This means changing the behavior and habits of individuals, including diet, exercise, dental habits, smoking, drinking, and the like.

The current human costs in these areas and the potential savings in human misery is enormous. I emphasize that some of these topics of research can be traced back 35 years in the behavioral sciences to research on the change of dietary habits during the Second World War by Kurt Lewin and his colleagues.

The behavioral component of major industrial problems is often little attended to. For example, in the next decade it is expected that $1 billion will be spent in office automation. The implementation of these systems has complex social and psychological problems associated with them, in that their impact on work roles and job functions is little understood. Indeed, the complexity of implementing new manufacturing systems is not well understood, despite the long-term commitment necessary by the firm and the heavy capital involved.

The success or failure of such industrial changes often directly hinges on human factors. Our ability to understand and predict such factors directly relates to basic research in the social and behavioral sciences that has been going on for decades.

Indeed, basic research in the social and behavioral sciences plays a much clearer and more impactful role in American institutions and industry than it is typically given credit for. There is a certain irony in that the findings of this research are perceived by others outside the country to have great export value.

The Japanese steel industry was mentioned earlier in testimony. It has been suggested in our media that the current superior position occupied by the Japanese steel industry is intimately related to their development of the notion of quality control circles. Quality control circles rest on two decisions or discoveries. One is a statistically based system of quality control, originally developed in this country, and the other is the notion of participative decisionmaking. The notion of participative decisionmaking rests very clearly on basic research in social psychology that is 35 or 40 years old, of which the Japanese are aware and use very explicitly.

One researcher has estimated that employee suggestions for changes in the manufacturing process occurred 10 times more frequently in Japanese companies than in American ones, along with a much higher rate of implementation of such suggestions. I also want to suggest that this kind of procedure is not put together in a slap-dash manner, as some of our steel executives have suggested doing. It is a tricky procedure. The research is there to be used, but it has to be implemented with some caution.

The Soviet Union has recently placed a great deal of emphasis on these sciences. For decades, research in social psychology was very actively discouraged, but within the last 5 years or so this attitude has changed dramatically. They are very actively encouraging social-psychological research in the school systems, in the work environment, and in basic laboratories. Their participation in and initiation of international meetings devoted to these discussions of basic research and methodology in the social and behavioral sciences has increased dramatically.

I have been invited to three of these weeklong meetings with the Soviets—twice in the United States, once when they cooperated with the Canadians and invited two Americans to come. They are very involved in this.

I suggest that the Soviets and the Japanese have discovered something perhaps the United States has yet to discover. Basic research in the social and behavioral sciences ultimately pays off for the society that supports it. Like any science, the research process itself is very complicated and progress is slow. One must often look across decades before it is obvious that clear progress has, indeed, been made.

We no more can offer a quick technological fix in the social and behavioral sciences than in any other science. It has been estimated that the development of social technology based on basic research is roughly on the order of years analogous to those it takes in the physical and natural sciences.

There is no doubt in my mind that progress in basic research and knowledge has proceeded steadily for decades. Further, this knowledge can be built on and utilized effectively in large-scale national problems. Dr. Clark Abt, who is the head of Abt Associates, has estimated that for every $7 spent in applied social research, research that is based upon basic research, $100 in savings has resulted to the U.S. society. Given the amount of money that the United States has invested in applied research, which is over $1 trillion, the cost of the basic research involved has been saved over and over again. It does pay for itself, and it does have very cost-beneficial connections.

For any science to accumulate knowledge, there must be continuity of funding. We ask this committee to give its strongest support for continuity of funding the social and behavioral sciences in fiscal 1983.

The future of our country may well rest on our collective understanding of human nature. Let us not undercut and jeopardize those sciences devoted to such understanding.

I thank you for your invitation to appear here today. I am open to questions at this time.

[The prepared statement of Dr. Kiesler follows:]

AAP ASSOCIATION for the ADVANCEMENT of PSYCHOLOGY

TESTIMONY OF

Charles A. Kiesler, Ph.D.

in collaboration with

THE AMERICAN PSYCHOLOGICAL ASSOCIATION,

THE ASSOCIATION FOR THE ADVANCEMENT OF PSYCHOLOGY

and

THE CONSORTIUM OF SOCIAL SCIENCE ASSOCIATIONS

before the

UNITED STATES HOUSE OF REPRESENTATIVES

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,

COMMITTEE ON SCIENCE AND TECHNOLOGY

Honorable Doug Walgren, Chair

on the subject of

RESEARCH SUPPORT FOR THE BEHAVIORAL AND SOCIAL SCIENCES

at the NATIONAL SCIENCE FOUNDATION

February 23, 1982

Mr. Chairman, Members of the Committee, my name is Charles A. Kiesler, Ph.D., I am Bingham Professor of Psychology, Head of the Department of Psychology, and Acting Dean of the College of Humanities and Social Sciences of Carnegie-Mellon University. I was formerly Executive Officer of the American Psychological Association, the nation's major psychological organization, representing over 65,000 members and affiliates. I also was Editor of the American Psychologist, and founding Vice-President of the Council of Applied Social Research. I am a fellow of both the American Psychological Association and the American Association for the Advancement of Science. I have served on the editorial board of four major journals in social psychology.

My interest in and involvement with the social and behavioral sciences at the National Science Foundation goes back some years. I have been a director or principal investigator of six different grants from the NSF. I served on the NSF Advisory Panel for Sociology and Social Psychology. Within the last year, I served on an NSF panel drafting a report on the "contributions of the social sciences to innovation and productivity" for consideration for inclusion in the annual report on science and technology. I also participated on the overview panel at NSF which critiqued and revised the 13 separate reports prepared for the NSF Annual Report on Science and Technology. Most recently, I participated in a panel advising how to implement the cuts already received in the social and behavioral sciences.

I should note that my own personal research interest has changed somewhat, such that NSF is no longer a central scientific funding source for my research. I do not receive any research funds from them now, nor do I anticipate applying for any in the near future. I am here, therefore, not to represent myself, but to convey the concerns of the larger social and behavioral science community.

On behalf of that community, I want to first sincerely thank this Subcommittee and its chairman for efforts last year in attempting to reverse the 75% budget cuts proposed for the social and behavioral sciences at NSF. This Subcommittee was the first legislative body to call for restoration of funds for the social and behavioral sciences. You authorized an additional $26 million for these disciplines to bring them up to 1981 levels. We are deeply grateful for that effort and the understanding that it reflects of our mutual goals for the social and behavioral sciences.

Eventually, as a result of other Congressional and Executive Branch actions, $11 million for the social and behavioral sciences were restored to the NSF budget. Again, we are grateful for this restoration, but we must point out that this end result still represents about a 40% cut from the original 1981 budget.

We ask that the social and behavioral sciences receive your continued backing for FY 83. My reading of the 1983 budget is that there are very small increases from FY 82 to 83. The program in memory and cognitive processes is slated for a $100,000 increase, social and developmental psychology $100,000, linguistics $100,000 and anthropology $100,000. Political science and sociology are slated for no increase. Although a small amount of money has been added across these programs, the increases do not nearly make up for past reductions. A recent review by a committee of the National Academy of Sciences chaired by Nobel Laureate Herbert Simon, showed that before the FY 82 cuts, funding in the basic social and behavioral sciences was extremely tight. The proportion of grant proposals actually funded was substantially smaller than in other sciences, and the average amount per grant also much smaller. For example, in my own field of social psychology before FY 82, only one grant proposal in six was approved in the National Science Foundation, the lowest in the Foundation. Indeed, if my recall is correct, the support in FY 81 for the social and developmental psychology program was less than when I served on that panel fifteen years before, at a time when it funded only social psychology.

The NSF budget and its support for the social and behavioral sciences cannot be considered in isolation. Because of budgetary cuts elsewhere in federal agencies, funding patterns have changedfor the social and behavioral sciences. For example in FY 81, an estimated 60% of the basic research in social psychology was funded by the National Science Foundation. In FY 82 this percentage will rise to 85%, largely becuase of a reduction in research funding and changes in funding priorities in the Alcohol, Drug Abuse, and Mental Health Administration and other places.

It is critical to the future of our country that we maintain a continuing commitment to the accumulation of basic knowledge in the social and behavioral sciences. These are the sciences that study human behavior and thought, and there is hardly a single national problem the solutions to which do not demand some understanding of human nature. As Dr. John Slaughter, Director of the NSF said in testimony before you last March, "The long-term solution to the energy shortage, productivity, new technology, and processes of innovation cannot be addressed without considering the individual in social context. Even in the way scientific research in itself is conducted and organized and new scientific findings are adopted and utilized, there is an indispensable human factor. Without understanding social and behavioral effects more thoroughly, we will not be able to accomplish the task of revitalizing our society, no matter what technological innovations may be found."

Indeed, it is generally unknown the degree to which basic social research is currently used in industry, social institutions, and the management sciences. For example, the notion of personnel selection and assessment is integral to the way we conduct business; both the general approach and the details of such procedures are dependent upon basic research that goes back to the selection of Army officers in World War I, personality testing developed in the Veterans Administration Hospitals and decades of achievement and ability testing in American education.

Today, we routinely employ survey research methodology in studies of the American economy; studies that business uses to make critical investment decisions, that government uses to predict future revenues and reaction to potential alternative policy strategies, and that innovators use to assess the market potential for new products. This methodology rests on accumulative scientific efforts going back to the 1920s relating to attitude measurement and statistical sampling techniques.

Human factors research is routinely employed in American business across the world. Examples are numerous, ranging from the layout of control rooms in nuclear reactors, the design of flight panels in airplanes, in which the cockpit design has been based on fundamental studies of eye-hand coordination, as well as a large number of studies in basic production units on the shop floor. Such studies contribute to human safety, to productivity, and to innovation.

Social and behavioral sciences have contributed directly to the management of the research and development process in other sciences. Existing literature has been directly related to the composition of research teams, the organizational structure of research organizations, and the relationship of R&D to other functions of a business firm, such as marketing. In some of the more innovative and productive American firms this knowledge is used routinely to guide research processes, often with direct increases in research productivity.

The management structure and processes of American industry are often based on straight-forward behavioral science research. This research includes studies of the relationship of morale and employee satisfaction to productivity, the effects of employee participation in decision-making on productivity, the nature of resistance to change of management practices, employee profit-sharing plans, and the relationship of styles of leadership to group productivity.

The potential of the behavioral sciences to contribute to the country's adjustment to rapidly changing technologies is also an area of great potential. As one example of the interplay between technology and human behavior, consider the problem of energy use. The development of energy sources and the refinement of techniques of production of energy are clearly problems for the engineering and physical sciences. However, the patterns of use of energy are almost entirely a question of human attitudes and behavior. Here conservation rests on such simple behaviors as turning a switch on or off, monitoring one's own behavior (as in the use of dishwashers or driving habits) turning up the thermostat in the in the summer and down in the winter, and the acceptance and/or purchase of alternative modes of supply. The behaviors and attitudes involved are simple and relevant questions easily researchable, and all could have an important impact on the overall use of energy and the patterns of use. I have suggested elsewhere that the nation's use of energy could be decreased somewhere on the order of 20 to 30 percent simply through well-researched behavioral techniques.

Another example of this interplay between human behavior and technology is the issue of medical compliance. This refers to the behavior of medical patients and the degree to which they will follow drug regimens and other prescribed behaviors. The cost of medical non-compliance is now estimated to be 30 billion dollars a year in the U.S. alone. But behavioral compliance is an area that has been researched in the United States for 30 or 40 years. The basic research and theory are there. Only the intermediate research connecting that basic research to the solution of this applied social problem remains to be supported and carried out.

Health economists and others have suggested that the next major step in improving the general health of the U.S. population is not a medical one, but a behavioral one. For example, the Surgeon General's recent report "Healthy People" examines the 10 leading causes of death in the United States and concludes that seven of these are in large part behaviorally determined and could be substantially reduced by changing behaviors. This means changing the habits of individuals, including those related to diet, exercise, dental habits, smoking, drinking, and the like. The current human costs in these areas and the potential savings in human misery is enormous. I emphasize that some of these topics of research can be traced back 35 years in the behavioral sciences to research on the change of dietary habits during the 2nd World War by Kurt Lewin and his colleagues.

The behavioral component of major industrial problems is often little attended to. For example, in the next decade it is expected that a billion dollars will be spent in office automation. The implementation of these systems have complex social and psychological problems associated with them, in that their impact on work roles and job functions is little understood. Indeed, the complexity of implementing new manufacturing systems are not well understood, despite the long term commitment involved and the heavy capital investment involved. The success or failure of such industrial changes, often directly hinges on human factors. Our ability to understand and predict such factors directly relates to basic research in the social and behavioral sciences that has been going on for decades.

Basic research in the social and behavioral sciences plays a much clearer and more impactful role in American institutions and industry than it is typically given credit for. There is a certain irony in that the findings of this research is perceived by others outside our country to have great export value. For example, our media often suggest that the current superior position occupied by the Japanese steel industry is intimately related to their development of the notion of quality control circles. These circles rest on two major concepts: a statistically based system of quality control, and participative decision-making. The notion of participative decision making rests very clearly on basic research in social psychology going back three or four decades. There is no doubt that this social technology has had an impact in Japan. One researcher has estimated that employee suggestions for changes in the manufacturing process occurred ten times more frequently in Japanese companies than in American ones, along with a much higher rate of implementation of such suggestions. (I note parenthetically that this research also suggests that participative decision making is not effective when applied in a slap dash manner. An employer not understanding these basic processes should apply these concepts with great caution.)

The Soviet Union also has recently displayed great interest in developing its knowledge base and understanding of basic processes in the social and behavioral sciences. For decades, research in social psychology was actively discouraged in the Soviet Union. Within the last five years or so, this attitude has changed dramatically. The Soviets are actively encouraging social psychological research in school systems, the work environment, and in basic laboratories. Their participation in and initiation of international meetings devoted to discussions of basic research and methodology in the social and behavioral sciences has increased dramatically recently.

The Soviets and Japanese have discovered something perhaps the U.S. has yet to discover. Basic research in the social and behavioral sciences ultimately pays off for the society that supports it. Like any science, the research process itself is complicated and progress is slow. One must often look across decades before it is obvious that rather sharp progress has been made. Social and behavioral sciences are no more able to offer a quick technological fix than any of the other sciences are. It has been estimated that the development of social technology based on basic research takes years, and the time it does take is very similar to R&D lags in the physical sciences.

There is no doubt in my mind that progress in basic research and knowledge has proceeded steadily for decades in the social and behavioral sciences. Further, this knowledge can be built on and utilized effectively in large scale national problems. Clark Abt, of Abt Associates, has estimated that for every seven dollars spent in applied social research (which builds upon the basic research already carried out) a hundred dollars in savings has resulted to society. Given the amount of money that the U.S. has invested in applied social research in the last few decades, the cost of the basic research which underlies it is only a fraction of the savings it has ultimately produced.

For any basic science to accumulate knowledge, there must be some continuity of funding. We ask this Committee to give its strongest support for continuity for funding the social and behavioral sciences in FY 83.

The future of our country may well rest on our collective understanding of human nature. Let us not undercut and jeopardize those sciences devoted to such understanding.

I thank you for your invitation to appear here today. If you have questions, I would be most pleased to respond.

Mr. **Walgren**. Thank you very much, Dr. Kiesler. That is a sound presentation. It brings me back to last year when some of those same thoughts where expressed. However, now with that on the record, I think we certainly should be able to make a very good case for the social sciences.

Dr. **Kiesler**. Thank you, Mr. Chairman.

Mr. **Walgren**. I appreciate that.

You saw, apparently, some of the effort to scale back in the social sciences in an advisory capacity. Can you relate the reductions that are reflected in the 1983 budget to any hard parameters, such as those raised by Dr. Slaughter about objectivity and data and the like?

Dr. **Kiesler**. No, sir. Over the years the social and behavioral sciences have received approximately 4 percent of the NSF budget. That in itself is a tight budgetary figure.

For example, of the Nation's doctorates in science and engineering, psychology alone has 11 percent of the doctorates in research. In the social and behavioral sciences we must be talking in the order of 15 or 16 percent of the Nation's doctorates funded with 4 percent of the money. That in itself does not sound very balanced and well-funded.

Dr. Slaughter also asked you for $85 million in increase in the NSF budget, of which he asked you for $800,000 in the social and behavioral sciences. Less than 1 percent of that increase goes to these sciences. That does not sound balanced to me.

Mr. **Walgren**. What sort of a process did they go through from your vantage point in giving them some advice? Or did they just ask you for the positive side and then you did not see the decisionmaking process itself?

Dr. **Kiesler**. I cannot tell you. The report, for example, originally requested by the Office of Technology Assessment on the contributions of the social and behavioral sciences to innovation and productivity will not appear in the President's science and technology message to the Congress. It was dumped in OTA. I do not know what these processes are. I just cannot tell you. It is not a sympathetic environment.

Mr. **Walgren**. There does not seem to be any rational basis.

Dr. **Kiesler**. I do not see a rational basis for it.

Mr. **Walgren**. Thank you.

Mr. Brown?

Mr. **Brown**. May I first echo what you have said with regard to the excellence of the arguments and the material presented by both of the witnesses. I think it gives me a much better understanding in detail of the rationale and justification for the support of continued research in these areas. I think it will enable us to convey some of this rationale to our colleagues much more effectively. I want to thank you for that excellent contribution.

Both of you have indicated in one way or another the importance of the current need for research in view of the kinds of social, economic, and other changes taking place in this country today. We are going through a period which some have described as reversal of a 50-year period in terms of the role of the Federal Government, and so forth. It would appear that there should be some measurable indication of this in society. Am I correct in this?

Would the continuity of some of these longitudinal surveys and data bases give us some correlations between the changes that are taking place in measures of the quality of life or some other index that would be useful at this time?

Dr. **Converse**. One would certainly think so. You have your finger on exactly our anguish at the notion that once again we will miss that measurement, or we may well miss that measurement, at these levels of funding. That is exactly why we are so concerned about it.

Dr. **Kiesler**. I agree with Dr. Converse. This is probably the worst time to cut those large data bases.

Mr. **Brown**. One of the specific changes that seems to be taking place is in the field of industrial relations where we see indications of massive change in attitude in at least some instances. I think to the recent settlement in the Ford case where they apparently are going to reverse a longstanding industrial relations attitude to work toward more worker participation, profit sharing, job security, and so forth.

It would seem to me that the Ford Co. would be vitally interested in some objective measurement of the contribution of this kind of policy reversal to market shares and other things of that sort. Is this a correct perception?

Dr. **Converse**. If they were, I would be amazed, yes.

Mr. **Brown**. Have they called you yet, Dr. Converse, for assistance in this problem?

Dr. **Converse**. Pardon?

Mr. **Brown**. Have they called you yet for any assistance in this problem?

Dr. **Converse**. No, for a rather simple reason. Well, there are two reasons. They are close-by, as you deduced.

Most of our data bases that I referred to are large national bases. Something of that sort, whereas we could pick reflections of it, if I were asking your kind of question, I would want something longitudinal.

Mr. Brown. I assume that a large company such as Ford has some access to consulting advice in this field in their industrial relations department.

Dr. Converse. It is very interesting. Dr. Kiesler was referring to some materials, the suggestion materials, for example, that were generated by a colleague of mine who has, in his salad days, spent a year on a Japanese auto assembly line and a year on a Detroit auto assembly line. He is the source of a lot of this kind of information. He has suddenly become very popular in terms of talks and seminars around the Detroit area, but there was not that kind of interest a few years ago.

Dr. Kiesler. This is Dr. Cole?

Dr. Converse. Right.

Mr. Brown. The contribution of American social science theory to the improvements of Japanese productivity has been fairly well put on the record by now. We are interested in observing that, of course.

On a somewhat larger scale, I have a vague recollection that the Japanese have been doing a fairly aggressive job in what you might call long-term or strategic marketing studies in a sense—efforts to predict what the citizens of Japan would feel would most contribute to the quality of life 10 or 20 years in the future, as a way of structuring their own economic efforts for the future.

Am I recalling this correctly? Are either of you familiar with any such efforts?

Dr. Converse. I am not closely familiar with that. I know they are working on it in Japan. I do not bring more to it.

I would like, if I might, to make one comment on the Japanese-American productivity comparison. It is often emphasized—especially in the engineering community—that human or social factors do not account for much of that productivity gap. Instead, the U.S. problem is mainly one of "hardware" matters such as the obsolescence of the plant and the like. There is obvious merit in that argument, and it would be a mistake to lose sight of it.

At the same time, enough is known about important human factors in productivity that the subject would seem to warrant a research investment of more than 3 cents on the R. & D. dollar, with the rest going to hardware matters. That would hardly seem to be an unrealistic allocation, yet we are currently being cut far below even those levels.

Mr. Brown. We have focused occasionally on the fact that there is at best a tenuous relationship between our investment in basic research and the hard sciences and you might say improvements in the productivity and innovation in this country.

We do not have enough information to establish clearly all of the connections. I think we take them as a matter of faith more than anything else. Our faith has been a little wanting insofar as the social sciences is concerned.

Mr. Chairman, I have no further questions.

Mr. Walgren. Thank you, Mr. Brown.

Let me ask whether you feel it has been a handicap in the social science area that research in that area as compared to the physical sciences may not have as concrete a relationship to innovation and productivity. Is this where they have gotten off the track? It is hard for me to understand how they could get off the track with respect to innovation and productivity in the social sciences. Could this be an explanation—that the social sciences lack some of the focus and the thrust that would identify them with innovation and productivity in everyone's mind?

Dr. **Kiesler**. I do not think so, the identification being a separate issue.

There was a great deal of applied research in the social and behavioral sciences going on in industry from the midthirties on. This research related, for example to morale and productivity, research related to creativity, research related to problem solving in a business environment or an industrial environment.

Such behavioral sciences were very early on that bandwagon, partly as a means to support their applied research but partly because it was a way to expand the basic research that had already been done, to test it in the field. It was an appropriate way to do it.

How that became disconnected in anybody's mind between then and now, or why it never became so firmly connected in the first place, that those were very active and very substantial contributions, I really do not understand. I do not think any historian of the social sciences understands it very well, either.

Mr. **Walgren**. I want to thank you very much for your testimony.

From a personal viewpoint, I think we may be suffering from nothing more than the gilded age of OMB, where I think we are coming through a year where OMB set this budget. It was not set by anybody who had any knowledge.

Dr. **Kiesler**. I think that is true, but OMB itself is employing the behavioral techniques and has a very active evaluation research group, for which they have hired social and behavioral scientists in order to evaluate particular public policies and recommend strategies of funding them. They may knock us on the one hand, but they sure use us on the other. [Laughter.]

Mr. **Walgren**. I sometimes think that perhaps the explanation may be as illogical as somebody over there does not like social engineering and, therefore, they came over to NSF and wiped out anything with the word "social" in it and anything with the word "engineering" in it. [Laughter.]

Well, let's hope it is not as mindless as that.

Thank you very much. I appreciate the record you have developed for the committee. As Mr. Brown indicated, I think that can be used with good effect. We are looking forward to trying to contribute on that level.

[Whereupon, at 5:05 p.m., the hearing adjourned.]

[Additional material submitted for the record follows:]

THE UNIVERSITY OF ROCHESTER
MEDICAL CENTER
SCHOOL OF MEDICINE AND DENTISTRY • SCHOOL OF NURSING
STRONG MEMORIAL HOSPITAL

[illegible]

January 19, 1982

Honorable Barber Conable
House of Representatives
Congress
Washington, D.C. 20515

Dear Congressman Conable:

Rarely have I written a letter expressing an opinion, but I feel the importance of this topic warrants the effort.

I am an Associate Professor at the University of Rochester Medical School and engaged in basic research involving the structure, replication and the expression of genes. Presently, this is a very exciting and promising research area because of its importance to genetic engineering and biotechnology. It has been estimated that the use of genetic engineering techniques will create multi-billion dollar additions to the agriculture, chemical, pharmaceutical and biomedical industries. Almost all large existing companies engaged in such endeavors of rapidly expanding their efforts in these areas, and over two hundred new companies engaged in genetic engineering in bio-technology have come into existence in the past five years. Presently, the U.S. has a lead in this area, but the Japanese have vowed to catch up within three years and be ahead within five years.

The basic research in biochemistry, genetics, microbiology and cell biology which lead to this new technology was sponsored mainly by the NIH and NSF. Recently, cuts in the budget for these agencies have seriously reduced funding for research and training of new scientists. Presently my research is well funded, but in some cases excellent scientists who have had productive research programs has lost their funding. It takes many years to train technicians and get programs running well. When funding is lost and the project must be drastically curtailed or terminated, it often means that much of the initial investment of funds in the project are lost. Also, when the training of new scientists is greatly reduced, future research and development is seriously hampered.

It is currently agreed that government funding must be cut, and every agency will have to arrange its priority in response to meet budgets. It is proposed by the administration that the private sector take up the slack in areas cut. There have been conferences on biotechnology where both industry and academia participated and where the problem of basic research funding was discussed. It was anticipated by industry that more funds would be pumped into applied, in-house, research but the government and university should not expect that a large part of the cuts in basic research to be made up by industry.

I think it is clear to everyone that the past funding of basic research has yielded many of the dramatic breakthroughs in technology that we have experienced in the past 20 years, such as computer technology and genetic engineering. I would make a plea that Congress will consider very carefully the costs versus the benefits of cutting the budgets of agencies sponsoring basic research. This I plea especially after hearing a report of the Defense Department's proposed budget for chemical and biological warfare.

Thank you for the many years of hard work, thoughtful representation of your constituents and responsible legislation.

Sincerely,

Helen Eberle

Helen I. Eberle, Ph.D.
Associate Professor

HIE:mt

Productivity and Utility: National Science Foundation and National Institute of Education Grants

Robert F. Boruch

This summarizes the products and uses of research generated by Northwestern University's Division of Methods and Evaluation Research with support of the National Science Foundation and National Institute of Education. The main purpose is to make plain the nature of the research and how the products eventually are used by public and private agencies.

All of the claims for use here can be corroborated.

Social Experiments and Program Evaluation

Northwestern's work in this area is dedicated primarily to understanding how to better estimate the effects of changes in social programs and of the reduction of programs. A parallel effort is dedicated to understanding how to assess social needs better and program implementation. The research is supported by the National Institute of Education and the National Science Foundation, and covers the following problems:

. Scientific problems:	Designing better, less equivocal ways of estimating program effects;
. Management problems:	Determining how well evaluations are done and how to get evaluations done better;
. Policy problems:	Developing evaluation policy at the local, state, and federal levels;
. Ethical and legal problems:	Resolving problems engendered by evaluations, developing model statutes, and legal research.

The basic idea is to get better information used more often in the policy process and in research. The evaluative information here includes administrative records, surveys, and large-scale experiments. The data may be numerical or non-numerical.

The products of this research have been used internationally and domestically. Reports on the use of randomized field tests for planning and evaluating development projects in developing countries have been prepared for the U.S. Agency for International Development and presented to mission directors in Africa. This work covers methodological and management issues in evaluation; there is an extended bibliography on methodology.

Guidebooks based on the research have been published by UNESCO's Division of Social Sciences and Applications. Their special focus is on case studies of remarkably high quality evaluations (excerpts have been published in Solomon, E. S. (Ed.), Evaluating social action projects. Paris: UNESCO, 1980). Northwestern staff were the only U.S. representatives selected for recent UNESCO conferences in Malaysia on evaluation in the Far East.

In the United States, investigatory agencies such as the U.S. General Accounting Office have used the work. At GAO, for example, our guidelines on assessing the quality of federal impact evaluations, developed with foundation support, have been adapted to GAO purposes and have been published in their "Guidelines on Impact Evaluation." Broad work on evaluation policy has been incorporated into two 1980 Reports to the Congress and the U.S. Department of Education on evaluation at the federal, state, and local levels of government, one report having been produced by the National Academy of Sciences and the other by Northwestern University. The same work has been cited in reports to the Office of Technology Assessment by Rand Corporation in special studies on educational evaluation in the United States. The Northwestern report and its recommendations were presented to the Institute for Program Evaluation at GAO in order to determine how GAO can exploit the research.

One of the policy papers generated in this series, "Implications of Educational Program Evaluations for Evaluation Policy," published in Review of Educational Research has won the research review award for 1980 from the American Educational Research Association.

Solutions to Ethical and Legal Problems in Research

Our foundation supported work on this topic is solution oriented. Attention has been dedicated partly to the problems of minimizing privacy degradation in research, assuring confidentiality of research records on identifiable respondents, and balancing needs for access to information in archives against privacy regulations, custom, or law governing archives.

Some of the recent work has been consolidated in a monograph: Boruch, R. F. and Cecil, J. S. Assuring confidentiality of social research data (Philadelphia: University of Pennsylvania Press, 1979). The monograph and our related published papers attend to statutory, statistical and procedural approaches to resolving problems. Related monographs now in press include Boruch, Ross, and Cecil's Solutions to Ethical and Legal Problems in Research (Academic, 1982) and Boruch and others' Data Sharing in Research. Each addresses other ethical and legal problems in research and explores solutions to them.

Work on the topic has been adopted by the Social Research Council's Committee on Program Evaluation in advising the U.S. General Accounting Office and is cited in both SSRC and GAO reports. It has been provided in testimony to the Privacy Protection Study Commission, was used and is cited by that group's report. Material has been adapted by the Panel on

Privacy and Confidentiality as Factors in Survey Response of the National Academy of Sciences Committee on National Statistics, and the American Psychological Association's Committee on Privacy and Confidentiality and cited in their reports.

Some of the published material has been used repeatedly over the last two years in workshops for members of federally required Institutional Review Boards that rule on ethics of research in universities. These workshops have been sponsored by the Office of Protection from Research Risks of the National Institutes of Health, the Association for Public Responsibility in Medicine and Research, and others.

The work has been recognized and used abroad as well. So for instance results of the research have been presented at Bielfeld and Cologne at the invitation of the organizors of these Germany sponsored conferences, at Stockholm for conferences sponsored by the Swedish Council for Social Science Research, and at Warsaw for the International Statistical Institute meetings. The work has been published in English and German in international professional journals, proceedings of these conferences and specialized monographs developed in Great Britain and Germany dedicated to information management and policy.

Secondary Analysis, Criticism and Data Access Policy and Practices

One focus of this work has been on assuring that records are available for use in federal program evaluation and related applied social research. One function of access is permitting reanalysis of earlier studies.

The most recent monograph on the topic produced primarily with NIE support is: Boruch, R. F., Wortman, P. M., and Cordray, D. S. (Eds.). Secondary analysis and program evaluation. San Francisco: Jossey-Bass, 1981. This volume expands earlier work including special journal issues such as: Boruch, R. F. (Ed.). Secondary anlaysis. New Directions in Program Evaluations. Volume 4, 1979, produced with NSF and NIE support. A specialized monograph covering statistical and inferential errors has also been produced by Leroy Wolins of Iowa State University, supported by our foundation grants: A Critical Commentary on Research in the Behavioral and Social Sciences (Ames: Iowa State University Press, 1982).

The work has been international in scope and utility. For instance, we have been invited to present papers on statutory obstacles and facilitating mechanisms for reanalysis at Bielfeld and the University of Cologne, Germany. Aspects of the work were in the 1980 Israel-U.S. Conferences on evaluation and Israel's Ministry of Education and Culture may adopt some of our recommendations.

The research has been used by a variety of federal agencies. The U.S. General Accounting Office for instance has capitalized on the reports and recognized the need for competing analyses of federal evaluations in its "Guidelines on Impact Evaluation." Recommendations to the Congress in the Holtzman Report by the National Academy of Sciences Committee on Program Evaluation suggested that routine critique and secondary analysis for major educational evaluations be made a formal policy by the Department of Education and incorporated into law by Congress. The issue of critique of data and evaluations is especially crucial if block grants give states more control of evaluation. Some states are very able, other are incompetent.

Our special review of the National Center for Educational Statistics' Condition of Education series, a review commissioned by the National Academy of Education, has been instrumental in changing NCES policy on the series. As a result of formal presentations to the NCES National Advisory Board and to the Director of NCES, we have been told that modifications will be made to the series graphs, glossaries, and content.

Sharing Research Information

Part of our work has been dedicated to assuring that information which should be accessible for research is indeed accessible. NIE and NSF have supported most of the work on the topic. The work includes development of procedures and guidelines for making information accessible, analyses of law bearing on access, and identifying obstacles to access through empirical research.

Much of the work is in the interest of improving scientific productivity and quality and to making sure that researchers can analyze data for scientific or policy purposes. Most of the work has focused on access to numerical (statistical) information on individuals. More recent work focuses on visual, narrative, and other non-numerical data.

The work has been of some interest outside the U.S. So for example, we contributed to the so-called Bellagio Principles on access to government data, based on the research. The Principles were developed at a meeting of representatives of six industrialized countries to reach a consensus on ground rules for accessing census, social security, economic and other data without breaching privacy law. The Principles have been published in at least a dozen journals and books here in the U.S. and abroad. They serve as a basis for access principles of the European Science Foundation.

Our more recent work is being used to feed into work by the National Academy of Sciences Panel on Data Sharing (Committee on National Statistics) and the Bureau of Justice Statistics (U.S. Department of Justice) Project on Access to state and local criminal records.

Research Policy and Management

The studies undertaken with NSF and NIE support bear on the development of research policy in the United States and abroad. It is difficult to determine exactly how the work has been used by decision-makers in this arena, but it is easy to lay out evidence that advice based on the work has been invited and presented in a variety of ways to individuals responsible for research policy or management.

Policy decisions have been informed partly through pro bono work, for instance, that involves translating our research findings into a form that addresses specific questions. We have been asked, for example, to develop memoranda for the Social Science Research Council on a variety of topics and the information has been incorporated into white papers and the like developed by SSRC to guide its activity over the last five years. The questions addressed bear on design of research during periods of scarce resources in 1981, alteration and research on social indicator systems for the United States in 1980, and social statistical research in 1979.

Similarly, formal contributions have been invited and they have been made to inform deliberations of the National Academy of Sciences Subcommittee on Data Sharing (Committee on National Statistics), the NAS Panel on Research on Quality of Work Life Experiments, the NAS Committee on Privacy and Confidentiality as Factors in Survey Response, and the Committee on Post Performance Evaluation of Basic Research. All of these contributions depended in a non-trivial way on the work supported by NIE and NSF at Northwestern University.

Similarly, we have been asked to contribute formally to the Aspen Institute's deliberations on policy for criminal justice research in Berlin and to the development of U.S. General Accounting Office policy on privacy and confidentiality of research data and policy on quality of evaluative research and have done this as well. More commonly, the contributions are a product of appointment of the principal investigator or staff to policy advisory boards. This includes participation in boards for the National Center for Educational Statistics' National Longitudinal Surveys, the GAO's development of an Institute for Program Analysis, the Social Security Administration's Cost Reduction Experiments, the Department of Health and Human Services' Seattle and Denver Income Maintenance Experiments, and others. Finally, it includes formal contribution as board members to development of the Joint Guidelines on Educational Evaluation by the American Educational Research Association and ten other cooperating institutions, to position papers elicited by the American Psychological Association on privacy and confidentiality.

Training

Any university-based research enterprise worthy of the label is also dedicated to advanced training. Northwestern's activity is no exception and both NIE and NSF have supported the research in which graduate students gain experience or capitalize on the experience they've accumulated elsewhere. Apart from this, specialized post doctoral programs supported by the National Institute of Mental Health and the National Center for Health Services Research have been dedicated to updating the skills of managers and researchers who have had substantial field experience.

So, for instance, former students and Fellows have gone on to reasonably important positions in academe, government and commercial sector. The government agencies to which post doctoral or predoctoral students have contributed as regular staff or managers include the Inspector General of the Department of Health and Human Services, the General Accounting Office, the National Institute of Education, the Federal Judicial Center (Research Arm of the Supreme Court), Oak Ridge National Laboratory and others. Former students hold or have held academic positions at Wheaton College, University of Colorado, George Washington University, C. W. Post University, Tennessee, City University of New York, University of West Virginia, Cornell University, and at institutions in Colombia, Norway, and Germany.

In the commercial arena, Northwestern has served as a training ground for individuals at Educational Testing Service, Abt Associates, NTS Corporation, and others.

Summary. of Statement for the Record by: Dr. F. Thomas Juster, Prof. of Economics, and Director, Institute of Social Research, University of Michigan

THE STOCKMAN BUDGET RECOMMENDATIONS, TAX POLICIES, AND ALL THAT

Whatever the merits or demerits of the proposals contained in the economic package proposed by the new Administation, one thing is clear: it has raised the level of consciousness of economists and other social scientists, caused them to rethink issues that had not been debated for some time, and produced a veritable ferment of political economy arguments of the sort not heard since the early days of the New Deal.

Unfortunately, very little of the public debate appears to be focused on what ought to be the major source of concern: what will the program do to improve the performance of the American economy, in particular what will it do to lower the inflation rate and improve the real growth rate? Instead, the discussion has focused on the wisdom or unwisdom of the various budget cuts that have been proposed. One can probably blame Mr. Stockman for that: budget cutting appears to have become an end in itself rather than the means to achieve some desirable goal like higher real growth or lower inflation. For example, the recent discovery by the Administration's that the revenue projections underlying the budget cut recommendations were too optimistic, and their conclusion that additional budget cuts had to be found in consequence, sounds as if the Administration believed that the only way to reduce the deficit was to cut expenditures.

Debate on the economic package proposed by the administration should focus on whether or not the ingredients in the package are well-suited to the Administration's objective--which for the most part are objectives shared by a great many others. The objectives, as I interpret them, are as follows:

1. Eliminate useless, wasteful or overly protective government spending and support programs.
2. Reduce the amount of intrusion by the federal government into private business decisions.
3. Lower the burden of taxes on both consumers and business.

The philosophy behind these objectives is that the elimination of waste, inefficiency, and excessive public support, combined with the reduction of regulatory and other intrusions that are thought to impede business investment, will permit a reduction of the tax burden. In turn, tax reduction will promote saving, encourage investment, and release private energies that are now hampered by the combination of excessive regulation and incentive-destroying tax burdens. One way to describe the administration's economic package is that it is designed to shift the distribution of output from consumption toward investment, and at the same time generate additional real output by restoring incentives that have been impaired by the burden of public sector tax-financed spending.

That set of ideas sounds plausible until you look at it carefully, and some of it holds up well even then. The most suspect part is what started out to be the main theme--the supply-side argument that reducing the public sector burden and thus permitting a reduction in taxes would increase the rate of growth in real output due to its positive impact on incentives, work effort and willingness to take risks. The new policy is very likely to have that effect on private business investment incentives --reduction of the regulatory burden, the presence of an administration known to be friendly toward business, and the prospect of tax and other investment incentives is quite likely to have a favorable effect on the level of private investment.

But that is not the part of the supply-side argument that has to carry the most weight: for the policy to work what has to happen is that a smaller public sector combined with a reduction in tax rates will increase the supply of labor hours, or the amount of effort per hour of labor, or some combination of the two.

There is quite a lot of empirical evidence on that issue, and all of it goes in the wrong direction for the supply-side argument. The evidence suggests that the lower the tax rate (and the higher after-tax wage rates), the less labor will be supplied to the market, while an increase in tax rates (and a reduction in after-tax wage rates) will cause more labor to be supplied--exactly the reverse of what the supply siders predict. The reason is that households apparently focus on a consumption target, which represents their aspirations. If tax rates are lowered they can reach the same target by supplying fewer hours, while if tax rates are raised it takes more hours to reach the goal. In the long run, it is quite possible that the effect of higher or lower tax rates on the supply of effort is nil--people adjust their targets in a way that keeps labor supply just about the same. But the evidence will not support the implicit contention in the administration's package--that reducing the size of the public sector and lowering the tax burden will result in more labor input and thus more output.

Some other parts of the administration's package are also suspect on the evidence. In particular, they seem to be counting on an increase in the real rate of return on saving to expand the amount of saving in the household sector, thus facilitating a rise in investment without exacerbating inflation. Again, the evidence suggests that no such effect will be found: higher real interest rates do not cause households to increase their saving, but instead appear to have no effect at all on total saving. Differentials in interest rates will of course get a rapid response from consumers, who will shift from one form of saving to another.

In the light of that evidence, it is interesting that the Administration seems adamant about the importance of large reductions in expenditures in the public sector on the grounds that they are needed to facilitate a large cut in taxes. One should certainly be in favor of reductions of public sector spending that are wasteful, inefficient or unproductive, but that argument stands on its own merits and does not need any response of labor supply to lower government spending and taxes. While many of the recommended budget cuts are designed to eliminate waste and inefficiency and to reduce support systems that have adverse incentive affects, for which the Administration warrants high marks, some of them seem designed solely to facilitate a tax cut which is unlikely to have the desired effect. The sensible solution is to gauge the size of the needed expenditure reduction by whether they eliminate waste, inefficiency, etc., then adjust the size of the tax cut accordingly.

Of course, there is another argument for tax cuts: old-fashioned demand-side economists have argued for years that tax cuts will stimulate consumer and eventually business demand, bringing an expanded growth rate of real output and permitting a modest gain on the inflation side because of the effect of expansion on productivity. But that is an argument for tax cuts without any reduction in expenditures--a prescription that is associated with inflation the way the Administration sees things.

Besides this basic flaw in the policy, there are other features of the budget recommendations that are difficult to rationalize. Quite properly, the economic package places strong emphasis on the need to increase investment incentives in order to expand the rate of productivity growth. But the treatment of investment activities that happen to take place in the public sector is curiously uneven. Two examples can be cited.

There are recommendations for substantial cuts in various types of housing subsidy programs, which are justified largely on the grounds of being somewhat lower priority than other social needs. Waste is not an issue here, but simply spending priorities. But all the recommended cuts are in programs designed to improve the housing stock of the lower half of the income distribution. There is an obvious counterpart policy for the uppper half of the income distribution that could have been suggested but was not--reducing the extent of preferential tax treatment for owner occupied housing, especially as it relates to the deductibility of mortgage interest. Calculations by the Congressional Budget Office suggest that a $10,000 limit on interest deductibility would reduce the subsidy to owner occupied housing by about a billion dollars a year, while a $5,000 limit would reduce the subsidy by about five billion dollars annually. Given the desirability of shifting resources from consumption to investment generally, reducing incentives to build houses seems an appropriate part of that strategy, and the limitation on interest deductibility seems an obvious candidate.

Second, while the Administration recognizes the importance of investment in basic research in the physical sciences as an essential feature of long-term economic recovery (because it sees links between such basic investments in research and technological innovation), its recommendations on investment in basic research in the social sciences are tantamount to elimination of public support for that activity entirely.

What seems remarkable about that difference in treatment is the plainly evident fact that many of the current problems facing the U.S. economy and society are not technological but behavioral-inflation is not a technology issue but a behavioral one, private investment is not sluggish because we lack new technology worth investing in, and even Three Mile Island turned out to be a near catastrophe because of inept human engineering rather than technical design flaws. The list is endless.

One would have thought that an administration committed to increasing saving and investment would recognize the crucial importance of investment in knowledge about the state of society and how it works, which is what the social sciences are all about.

And the Stockman recommendation on basic social science research can hardly be justified as essential to cutting the budget down to tolerable size--the cost of the entire enterprise is equivalent to a rounding error in the increase recommended for the Department of Defense budget. As one of my colleagues remarked: eliminating social science research in an effort to reduce the size of the public sector is a little like trying to slim down an overweight giant by removing his eyes and ears.

1983 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

THURSDAY, FEBRUARY 25, 1982

House of Representatives,
Committee on Science and Technology,
Subcommittee on Science, Research and Technology,
Washington, D.C.

The subcommittee met, pursuant to call, at 12:35 p.m., in room 2318, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Mr. **Walgren.** I want to apologize first to the people interested in the hearing and to other members. We had these hearings on Education originally scheduled for last week but changed them, because the Congress changed its schedule. We have had to start the other hearings in order to accommodate the schedules of the witnesses, particularly Dr. Branscomb. This is a difficult time to hold a hearing because other Members have prior commitments. But I expect they will be along shortly.

I would like at the outset to say that this is the second day of hearings on the fiscal year 1983 authorizations for the National Science Foundation. As we noted on Tuesday, we will be devoting this hearing almost exclusively to the questions of science and engineering education.

This committee spent several days last year in reviewing the Foundation's programs and the issues concerning science and engineering education. I would like to insert at the end of my statement a summary of the testimony we received last year.

In view of the importance of these programs, the committee recommended a substantial increase in funding for that directorate. Though the final numbers were reduced, it was very clear the sense of Congress was that these programs be continued and hopefully strengthened in the next budget.

Quoting from our report language the committee issued last year, and I quote,

> While recognizing the need for budgetary stringency in Federal spending, the committee feels that the elimination of the Science and Engineering Education Directorate as proposed by the administration is unwise and unwarranted.

Sadly the administration has not followed the recommendations in that report. Instead they have presented a request reducing the science and engineering education programs a further 30 percent and eliminating all but the graduate fellowship program. More recently, in what struck me as something that could be characterized only as a "preemptive strike," Dr. Slaughter has announced his intent to disestablish the Director for Science and Engineering Education. That seems to me to be going in the wrong direction.

Certainly, no one is questioning Dr. Slaughter's or the administration's right to manage the Foundation. However, this decision goes far beyond a simple organizational change. It is a policy change of far-reaching and critical importance. Rather than build on the experience and expertise that exists, they are proposing to dismantle what is there and put in its place a commission. Presumably a commission that will come forward at some point in the distant future, and make its recommendations. We will then be forced to rebuild once again.

Given the atmosphere of this administration to cut back Federal personnel, it strikes me that it will be very difficult to rebuild at a future time. I would like to bring to the attention of my colleagues on the committee and the administration that the concern with precollege education is not a new one. In hearings before this committee, historically there has been substantial emphasis on science education function and particularly the precollege science education function. In 1959, Dr. Alan T. Waterman, the Director of NSF at the time and one who set traditional directions in our Government's effort in this area said,

> In our view, the development and administration of programs . . . to make it possible for these science and mathematics teachers to improve their knowledge of the current status of subject matter in science and mathematics is of primary importance.

From that time on there have been repeated studies in this area. A study by this Committee on precollege education published in January 1976 pointed to a number of problems in the Foundation's precollege education programs and I quote again:

> In recent years, at least since 1970, two factors seem to have influenced the precollege programs. The first is a reported antipathy by the Office of Management and Budget toward forms of activity that might be classed as continuing aid to education. . . . The second factor innfluencing NSF's precollege activities seems to have been a growing concern among its administration and among the members of the National Science Board, about competing needs for funds, particularly the growing problem of sufficient funding for university level programs. These concerns seem to have led the Foundation to place an even lower priority on precollege education.

In other words, it would appear that the major problem has been the systematic diminution of these precollege education programs by OMB and NSF over the past decade. And it seems that this trend is continuing and our problems seem to lie in those same areas today.

I would like to add at the end of this statement a full executive summary of this report for the record.

It seems we have now come to just about a complete circle. NSF would eliminate all but a few graduate fellowship programs. It would pursue yet further studies on precollege education in order to, and I quote Dr. Slaughter from Tuesday, "to provide action and not rhetoric." I would suggest the 18-month proposed Commission study will do just the opposite.

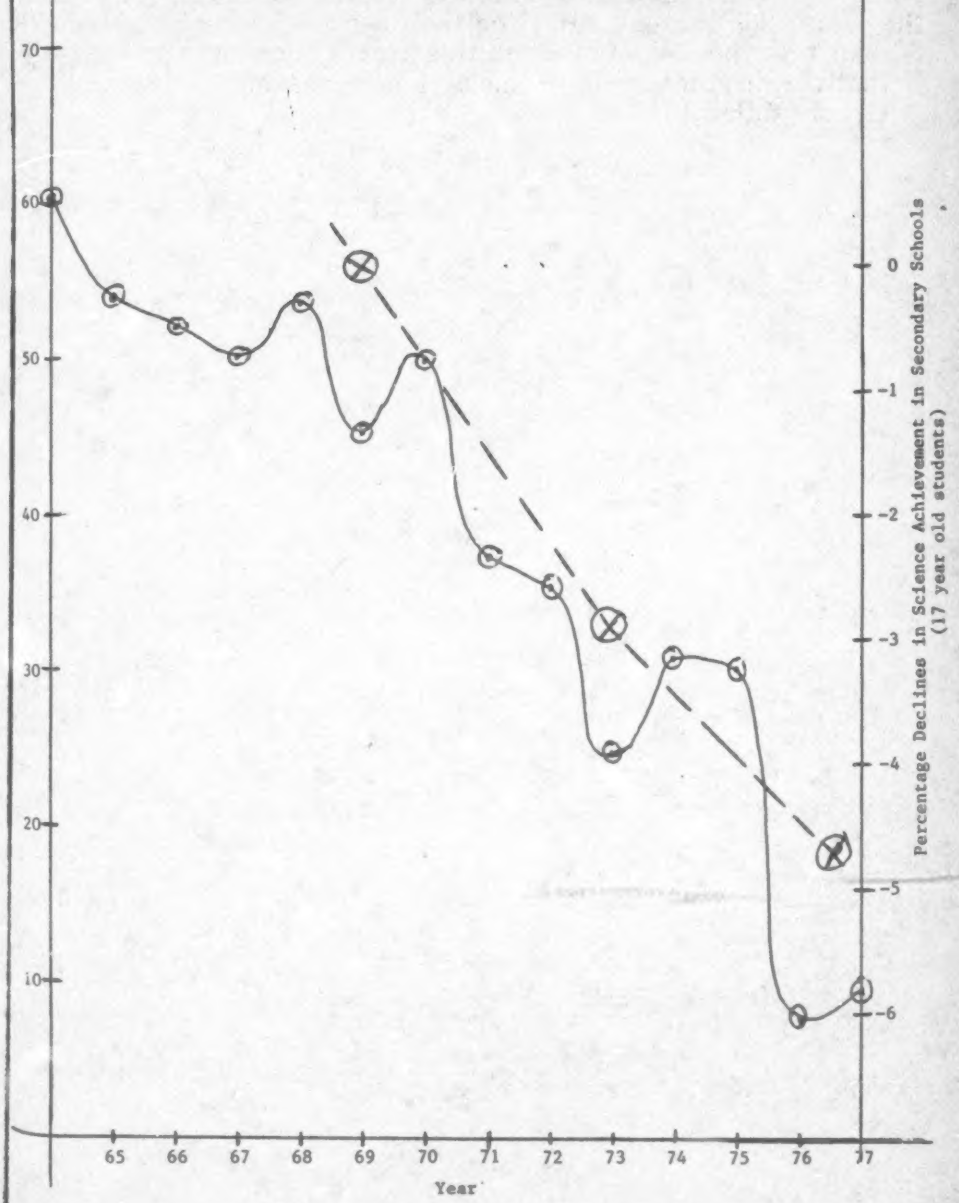
I personally think it a mistake to dismantle this program. And we will hear testimony today about this period and where we have come from and where we are today.

I don't think it is any accident that when you graph the performance of science achievement at the secondary level, it follows almost with a direct correlation the decline of the funding efforts by NSF in precollege science education.

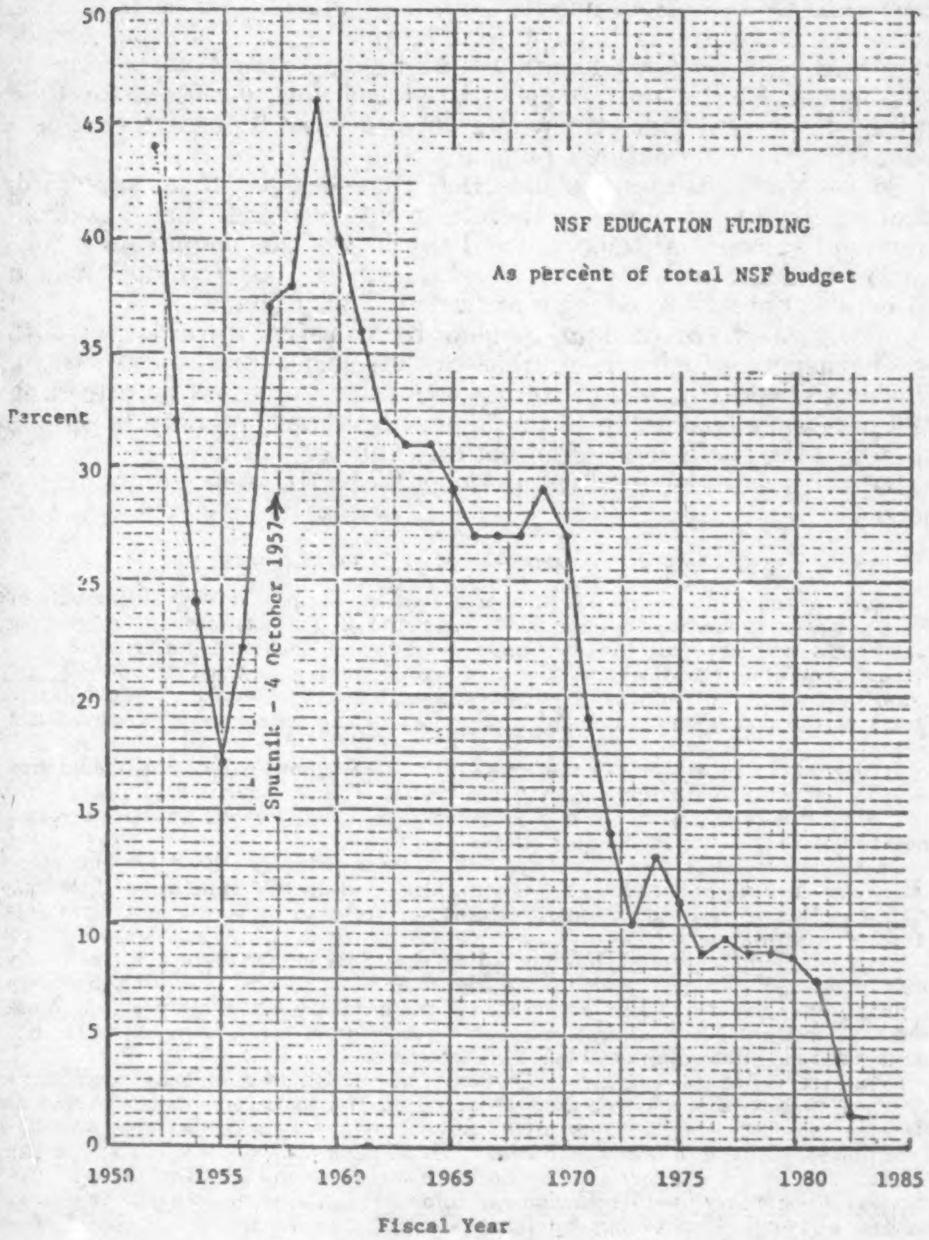
As you can see this graph of science achievement scores compared with NSF funding of precollege science education shows from the years 1965 through 1977, and the lines are almost congruent. It is clear that the lack of effort in this area is correlated and certainly that the need for effort in this area is increasing.

[Graphs follow:]

DECLINES IN NSF SUPPORT OF PRE-COLLEGE SCIENCE EDUCATION CORRELATED WITH DECLINES IN SCIENCE ACHIEVEMENT AT THE SECONDARY LEVEL



GRAPH #1


NSF EDUCATION FUNDING
As percent of total NSF budget
Percent
50
45
40
35
30
25
20
15
10
5
0
1950
1955
1960
1965
1970
1975
1980
1985
Fiscal Year
Sputnik - 4 October 1957

GRAPH #2

At the same time, I think we ought to bear in mind that in the past this kind of effort has had much greater emphasis than it is receiving today in the science foundation. In 1960 as a percent of the total NSF budget education funding was almost 45 percent of the budget. That same category is reduced now, projected for 1983 not at 45 percent, but somewhere down around 3 percent or 2 percent from the Foundation's budget.

So we are continuing a direction that has led to a worsening problem in this area, where there is great consensus that this problem is of substantial importance. I think it is this committee's obligation to address that directly and encourage the Foundation in a direction that will provide an answer to that problem.

In my view, we should instead be working towards ways to strengthen these education areas that are considered most critical. We must make, instead of rolling back, some progress by providing the necessary leadership in implementing these program directions mandated in the Science Foundation's charter.

[Opening statement of Hon. Doug Walgren, plus summary follows:]

OPENING STATEMENT OF HON. DOUG WALGREN

Today we begin the second day of hearings on the fiscal year 1983 authorizations for the National Science Foundation. As we noted on Tuesday we will be devoting this hearing exclusively to the questions of Science and Engineering Education.

This Committee spent several days last year in reviewing the Foundation's programs and the issues concerning science and engineering education. I would like to insert at the end of my statement a summary of the testimony we received last year.

In view of the importance of these programs the Committee recommended a substantial increase in funding for that Directorate. Though the final numbers were reduced it was certainly the sense of Congress that these programs be continued and hopefully strengthened in the next budget.

Quoting from our report language: "While recognizing the need for budgetary stringency in Federal spending, the Committee feels that the elimination of the Science and Engineering Education Directorate as proposed by the Administration is unwise and unwarranted."

Sadly, the Administration has not followed our recommendations. Instead they have presented a request reducing the science and engineering education programs a further 30 percent and eliminating all but the graduate fellowship program. More recently, in what I have characterized as a "preemptive strike" Dr. Slaughter has announced his intent to disestablish the Directorate.

I am appalled at this suggestion. Certainly, no one is questioning Dr. Slaughter's or the Administration's rights for reorganization and management. However, this decision goes far beyond a simple organizational change. It is a policy change of far-reaching and critical importance. Rather than build on the experience and expertise that exists they are proposing to dismantle what is there and put in its place a Commission. Presumably the Commission will come forward at some point in the distant future, and make its recommendations. We will then be forced to rebuild once again.

Given my experience, and given the atmosphere of this Administration to cut back federal personnel, I fear that rebuilding will be very difficult and very expensive at a future date.

I would like to bring to my colleagues' and the Administration's attention that the concern with precollege education is not a new one. In hearings before this Committee (then called the Committee on Science and Astronautics) Dr. Alan T. Waterman, the Director of NSF in 1959 said:

"In our view, the development and administration of programs * * * to make it possible for these science and mathematics teachers to improve their knowledge of the current status of subject matter in science and mathematics is of primary importance * * *"

I can point as well to studies by this Committee in 1975 on precollege education. That report published in January 1976 pointed to a number of problems in the Foundation's precollege education programs and I quote again:

"In recent years, at least since 1970, two factors seem to have influenced the precollege programs. Both are difficult to substantiate concretely. The first is a reported antipathy by the Office of Management and Budget toward forms of activity that might be classed as continuing aid to education. According to these reports, OMB has taken the position that it might be acceptable to undertake specific projects to aid precollege schools, but the repetitive support of activities, such as discipline-oriented summer institutes, was to be discouraged.

"The second factor influencing NSF's precollege activities seems to have been a growing concern among its administration, and among the members of the National Science Board, about competing needs for funds, particularly the growing problem of sufficient funding for university research programs. These concerns seem to have led the Foundation to place an even lower priority on precollege education, as two Board members indicated in testimony to the House Committee on Appropriations for fiscal year 1974."

(I would like to add the full executive summary for the record at the end of this statement.)

In other words, it would appear that the major problem has been the systematic diminution of these precollege education programs by OMB and NSF over the past decade. Strangely enough it is in just this area where our current problems are admitted to reside.

We have now come to just about a complete circle. NSF would eliminate all but a few graduate fellowship programs. It would pursue yet further studies on precollege education in order to, and I quote Dr. Slaughter from Tuesday, "to provide action and not rhetoric." I would suggest the 33 month proposed Commission Study will do just the opposite.

I think it a mistake to dismantle this program. I think we should instead work toward ways of strengthening these areas considered most critical and get on with providing the necessary leadership and guidance mandated by law for the Foundation.

HEARING SUMMARY EXTRACTS

SCIENCE AND ENGINEERING EDUCATION

The Subcommittee on Science, Research and Technology devoted two days to testimony on the Science and Engineering Education Directorate (March 3, and March 10, 1981). Witnesses were as follows:

Dr. John Slaughter, Director, National Science Foundation;
Dr. Don Langenberg, Deputy Director, National Science Foundation;
Hon. Mike McCormack, a former Representative from the State of Washington;
Dr. Carl Sagan, Professor of Astronomy, Cornell University;
Dr. H. Guyford Stever, Chairman, Assembly of Engineering, National Academy of Sciences—National Academy of Engineering and former Director, National Science Foundation;
Dr. Donald McCurdy, President, National Science Teachers Association;
Dr. Daniel Drucker, Dean, College of Engineering, University of Illinois;
Dr. Samuel Hulbert, President, Rose Hulman Institute of Technology;
Lionel Baldwin, Dean, College of Engineering, Colorado State University;
Hon. Richard W. Hays, Acting Assistant Secretary for Educational Research and Improvements, Department of Education;
Joan Ganz Cooney, President Children's TV Workshop;
Dr. James Rutherford, Science Education Office, American Association for the Advancement of Science;
Dr. Lilli Hornig, Higher Education Resource Services, Wellesley College;
Dr. Robert Q. Marston, President, University of Florida (testifying for the Association of American Universities);
Dr. Arliss Roaden, President, Tennessee Technical University (testifying for the American Association of State Colleges and Universities);
Dr. James Powell, Vice President and Provost, Oberlin College (testifying for the Great Lakes Association/Independent Colleges).

A. Proposed termination of the NSF science and engineering education programs

Dr. Slaughter justified the termination of the NSF Science and Engineering Education programs (the only funds to be provided were for phase-out of fellowships that had already been awarded, in the amount of $9.9 million). He justified this action by saying that the education programs were secondary to NSF's mission to support research, and that only top-priority programs could be supported under the Administration's effort to reduce the Federal budget. In hearings on other topics relating to the NSF budget, it was established that the decision to terminate the science and engineering education activities was made by OMB and conveyed to NSF officials as a command. There had not even been time to inform the National Science Board of the OMB directive prior to accepting the OMB position. When asked whether this termination of funds for science and engineering education constituted a confict with NSF's statutory authority to promote the improvement of science and engineering education at all levels, Dr. Slaughter replied that it did not do so in his opinion. He indicated that he would seek the restoration of funds for science and engineering education in the next fiscal year (1983). He also pointed out that it would be much easier to reconstitute education support if many of the programs mandated in recent years were eliminated by Congress, so that NSF would have greater flexibility. His final major point was that NSF would still be providing a great deal of support for graduate education through its research grants in the form of research assistantships, even in the absence of the former programs in science and engineering education.

B. Support for the NSF proposal to eliminate support for science and engineering education in fiscal year 1982

Dr. H. Guyford Stever, former director of NSF, concurred that science and engineering education programs were second in priority to research support programs at NSF. However, he pointed out that the need for both teaching and research equipment is acute, that the summer institutes for teacher training and the fellowships programs have been highly effective, but that the programs in curriculum development have had mixed results. He called for greater support of science education by industry.

C. Criticisms of the NSF proposal to eliminate support for science and engineering education in fiscal year 1982

Mr. McCormack, Dr. Sagan, Dr. McCurdy and Dr. Rutherford were sharply critical of any move to reduce support to science and engineering education at the precollege level. They cited the importance of science to an educated non-scientist citizenry who have to understand the impacts of science and technology on their lives in order to control the safety of their surroundings and to enhance their own well-being. They also recognized the importance of high quality precollege science training for those who might go on in science careers. They pointed to other countries as providing better science education than the U.S. They concurred that the termination of science and engineering education support by NSF would be highly detrimental for the future of the United States.

Dr. Powell stressed that science education is a continuing process for each student, and that no line of demarcation can be made between education at the graduate level and education at earlier levels. He pointed out that support at the graduate level is of no assistance to the needs that exist at earlier levels of science and engineering education, and stressed that the flow of well trained students into the graduate level depends directly on the quality of training provided at the undergraduate level.

Dr. Roaden voiced concern for a deterioration in the quality of schools offering science and engineering education.

Dr. Marston voiced a strong objection to the proposed termination of education programs on policy grounds, saying that the Congress had recently reaffirmed the importance of science and engineering education by specifically providing for the retention of activities at NSF when the Department of Education was established.

Dr. Lilli Hornig emphasized the importance of programs designed to attract women into science careers, two of which were to be terminated with the elimination of the science and engineering education programs.

D. The pressing need for more students and faculty in computer sciences and engineering.

Drs. Drucker and Baldwin called attention to the particularly pressing needs in the fields of computer sciences and engineering, where acute personnel shortages exist. Salaries for B.S. degree graduates are so very high in these fields that insufficient numbers of students are attracted in graduate training. The attraction of high salaries for more experienced and highly trained engineers and computer scientists is pulling faculty out of universities and attracting young Ph.D.'s into industry, with the result that about 10% of the available positions for faculty in these fields are unfilled. Concurrently, according to these witnesses, there has been an increase of about 30% in the numbers of students in these fields. Dr. Drucker called for an immediate program of 1) traineeship-fellowships, 2) an instructional equipment program, and 3) an expanded program for engineering research, at a total cost of about $40 million per year after reaching a full-scale level of operation. Dr. Baldwin called for a program to make greater use of educational technology in universities to overcome teacher and faculty shortages.

This particular problem of shortages in computer sciences and engineering was discussed in greater detail in the hearings on the Engineering Directorate.

Mr. WALGREN. With that, I would like to recognize other members for any comments they might have at the start. And I would like to recognize first Mr. Gregg.

Mr. GREGG. I have no comments, Mr. Chairman.

Mr. WALGREN. Mr. Lundine.

Mr. LUNDINE. Mr. Chairman, I have a statement I would ask unanimous consent to insert in the record at this point.

Mr. WALGREN. Without objection that will be done.

[The prepared statement of Mr. Lundine follows:]

PREPARED STATEMENT OF CONGRESSMAN STAN LUNDINE

The recent announcement by the National Science Foundation to eliminate the Science and Engineering Education Directorate in the National Science Foundation, and to cut back on funds available in the upcoming fiscal year for science education activities at N.S.F. causes me serious concern. In fiscal year 1981, we funded the N.S.F. Science and Education Directorate at a level of $70.7 Million, which included a variety of activities ranging from fellowships and traineeships to general public education. For the current fiscal year, while this subcommittee sough to fund this program at a level of $75 Million, under budget pressure from the President the program was reduced to $20.9 Million. And now, for fiscal year 1983, this Administration is proposing only to preserve $15 Million in funding for science graduate fellowships, and to create in place of the Science and Engineering Education Directorate, yet another government commission to explore pre-college education and science education policy options for the future.

While I can appreciate the complexity of the problem we are facing in scientific and engineering education and the need to take time to develop a coherent strategy to broaden our efforts to attack this problem, I question whether the elimination of the directorate in the N.S.F. and the "back to the drawing board approach" that seems to be embodied in the N.S.F. proposals do not represent a fundamental downgrading of emphasis on this problem at the federal level.

We have seen the familiar pattern in other areas where programs are downgraded or eliminated supposedly temporarily and commissions are created to develop supposedly new policy options which somehow never get implemented or even seriously discussed.

If this history repeats itself in the area of science and engineering education, this country will be in serious trouble. The whole area of education, and particularly the crisis in available technically trained manpower and engineers, is central to our effort to reindustrialize our declining industries and keep pace in an increasingly competitive and high technological world. Moreover, as our national defense turns more and more to high technology to insure the necessary margin of safety against armed aggression, we will need larger and larger number of technically trained military personnel to effectively utilize our military hardware.

We are becoming too familiar with descriptions of the problems—we now lack, and will continue to lack in the foreseeable future an adequate quantity of high quality engineers; our engineering faculty at our universities is disappearing, our instructional equipment at our universities is obsolete, and the engineering curriculum being taught in our schools is in many respects outdated and in need of revision. In addition to this, for a variety of reasons, our pre-college science education in our primary and secondary schools is failing to prepare our young people with the fundamentals necessary to succeed in a high technological society.

These are all serious problems which must be factored into a national effort to prepare us for the future. The National Science Foundation certainly can only be a small part of this overall effort, but as the leaders in scientific excellance and as those in many respects most capable of paving the way for innovative programs in this area, we should not be reducing your resources through budget cutbacks. If there are programs or research projects under your Education Directorate which you feel have not been effective, or for some reason should not be continued, we should discuss these and eliminate those that cannot be justified. They must be replaced, however, with a program which contains a strong commitment to exercise effective, action-oriented leadership in assisting our communities and universities in this area.

As we proceed with our discussion today, I think this committee should note for the record that the largest source of federal civilian agency support for engineering education is through student financial assistance programs, which this Administration is proposing to eliminate in the upcoming fiscal year. According to G.A.O. about 93 percent of engineering students who receive federal assistance do so through the Department of Education student assistance programs. The Administration's proposal to eliminate funding for this crucial program naturally increases the skepticism regarding this Administration's commitment to developing a national strategy to insure that we have adequate and quality scientific and engineering manpower to meet out future needs.

I do hope that through this dialogue today and in the days ahead we can arrive at a mutually agreeable framework for proceeding with work in this critical area in the upcoming fiscal year. Our nation's future capability to innovate, to remain economically competitive, and to provide for national security, is dependent upon it.

Mr. WALGREN. Mr. Shamansky.

Mr. SHAMANSKY. I will not repeat my statement of the other day, Mr. Chairman, except to say they are very deeply held views and I think something can result from these hearings that will save these vital programs.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you.

Mr. McCurdy.

Mr. McCURDY. Thank you, Mr. Chairman.

I have a statement I would like entered into the record without objection. I would also comment that I am deeply concerned by the budget request we have seen and, I think, the failure to address this very important issue which is to me so apparent.

I serve on both the Armed Services Committee and this one. I think the two are very closely related. I think the problems we have in manpower and readiness are very closely linked to the manpower shortages of engineers. I think it is time that we as a nation face this question. I hope that we can bring greater attention to the problem, and again elevate it to the level I think is necessary.

OPENING STATEMENT BY REPRESENTATIVE DAVE McCURDY

Mr. Chairman, I am extremely disappointed in the administration's fiscal year 1983 budget request for the NSF Science and Engineering Education Directorate. The $15 million request would result in the elimination of all science and engineering education programs. The sole survivor would be the graduate fellowship program. One of NSF's explicit missions, stated clearly in its enabling legislation, is to strengthen science and engineering education at all levels; yet, this budget proposal contains no funds for secondary and college science and engineering education programs. I was even more distressed to learn that, prior to any congressional discussion or action on the fiscal year 1983 proposal, Dr. Slaughter has announced the elimination of the Science and Engineering Education Directorate and that he plans to RIF an additional 53 Directorate personnel.

All of this comes at a time when we are faced with a serious crisis in science, math and engineering education and an incredible shortage of engineering, scientific and technical personnel. Not only has the quantity and quality of science and math education in our secondary schools declined, our schools are also faced with serious shortages of qualified math and science teachers. The education and manpower crises are reducing our productivity, hampering industry, slowing our defense preparedness and leaving us with a generation of young people who are scientifically illiterate. I think that all of us here agree that the testimony we heard during our hearings on the engineering and technical manpower shortage only underscores the seriousness of the problem and the inconsistency and short-sightedness of eliminating NSF's science and engineering education programs. It's important to remember that a well-educated populace is what allowed us to advance faster and farther than any other country in the world. During a time when we are concerned about losing our technological superiority, we just cannot afford to decimate programs such as these.

I am looking forward to hearing our witnesses today and hope that we can all work together to improve science, math and engineering education.

Mr. WALGREN. Thank you, Mr. McCurdy.

Mr. LUNDINE. Mr. Chairman, may I make one comment in addition to entering my statement in the record?

I realize these witnesses did not come here to defend the administration except in regard to the National Science Foundation or Board. But I am very disturbed over the idea that the answer to every major problem facing America is to appoint a board or commission to study it. I mean if there was ever a time when we needed action about things, it seems like it is now.

No matter if it is fraud or abuse, or how we are going to finance housing or a plethora of other subjects, the answer is we are going to have a study commission. One thing I hope they will address is why that is an answer to the particular problem at hand.

Mr. WALGREN. Thank you, Mr. Lundine.

With that we want to welcome to the committee the representatives and people who are responsible for administering the budget the Congress provides to them, the Director of the National Science Foundation, Dr. John Slaughter. We are especially pleased that you are here, accompanied by Dr. Lewis Branscomb, Chairman of the National Science Board and Dr. Donald N. Langenberg, who is the Deputy Director of the National Science Foundation. Dr. Branscomb has a time problem, and we are very anxious to accommodate him.

So, Dr. Slaughter, we are pleased you are here. Of course any written statements will be made a part of the record as a matter of course. Please proceed in however you feel is the most effective way to communicate your program to the committee.

STATEMENTS OF DR. JOHN B. SLAUGHTER, DIRECTOR, NATIONAL SCIENCE FOUNDATION; DR. LEWIS BRANSCOMB, CHAIRMAN, NATIONAL SCIENCE BOARD; AND DR. DONALD N. LANGENBERG, DEPUTY DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. SLAUGHTER. Thank you very much, Mr. Chairman.

I hope, during our presentation this afternoon, we will have an opportunity to address the point you raised, Mr. Lundine. I simply repeat my comment of yesterday: We do not think a study commission is an answer, either. I will try to show why through my comments today.

We are pleased this afternoon to discuss the fiscal year 1983 budget of the National Science Foundation, for science and engineering education. I will make opening comments, and then Dr. Branscomb, vice president and chief scientist of IBM and Chairman of the National Science Board, will comment because he must leave by 1:30. Then I will complete our testimony before we receive your questions

As you know, NSF's budget for science and engineering education in fiscal year in 1983 requests $15 million to support National Science Foundation graduate fellowships. A minimum of $1.5 million of the total will be used to support minority graduate students.

The rationale of the Foundation request for support of graduate fellowships is well known to this committee. The assumption we used in establishing the total budget request, including graduate fellowships, was presented to the committee on Tuesday; I will not repeat it.

It is important, however, for me to say that I have too much respect for the members of this committee, as well as for my colleagues at the National Science Foundation and representatives from the science education community, many of whom are here today, to attempt to convey the impression that I believe the graduate fellowships alone discharge the full responsibility of the Foundation in science and engineering education, or that their presence in our budget adequately addresses the most critical issues facing this country in scientific and technological education.

Those issues can be stated forthrightly. They include the declining requirements for achievement by students in mathematics and science to qualify for graduation from the Nation's high schools. They include the correspondingly low requirements for preparation by students who qualify for entry into higher educational institutions. They include lack of incentives and rewards for teachers of mathematics and science, and a corresponding decline in the quality of preparation by those teachers. They include severe shortages in mathematics, physics, chemistry, and biology teachers in the secondary schools. They include the high incidence of persons unprepared, unlicensed, or uncredentialed to teach those courses in the high schools. They include curricula which fail to consider current needs and achevements in science and technology. They include courses based upon memorization, rather than experimentation, and an absence of opportunities for students to learn through creative experiences. They include classrooms with archaic equipment, much in such disrepair that it cannot be used in any kind of meaningful learning.

These are some of the educational problems faced by this country in science, mathematics, and technology, and these are some of the problems that need to be addressed.

The National Science Foundation is not unmindful of these problems, even though the fiscal year 1983 budget for science and engineering education merely requests $15 million for NSF graduate fellowships. That expenditure is warranted on its own merit because it represents the most important opportunity for some of the Nation's outstanding graduate students to obtain support for their education and to conduct research in the sciences and engineering. It is a program which has produced Nobel laureates and National Medal of Science winners. It is a program which is universally acclaimed as the most important graduate fellowship program in the sciences in this country.

The other issues that I have mentioned, however, are not unrecognized. In fact, they represent a significant part of the Foundation's thinking and are reflected in other parts of the NSF budget.

Before I address NSF's plans in more detail, I am going to turn the microphone over to Dr. Branscomb for his comments concerning the role of the National Science Board in setting the budget strategy for fiscal year 1983, in reviewing science and engineering education, and in establishing the Commission on Precollege Education in Mathematics, Science, and Technology, the vehicle by which we believe NSF has an opportunity to contribute significantly to the assessment of the problems that I just outlined.

Dr. Branscomb.

Dr. BRANSCOMB. Thank you, Dr. Slaughter.

With your permission, Mr. Chairman, I will submit my written testimony for the record and provide you an oral summary.

In my prepared testimony, I summarize the process the National Science Board uses each year with the Director and his top staff in setting budget priorities. I won't repeat it now, but I do want to convey to you the seriousness with which the Board considers and participates in the establishment of Foundation priorities.

Our starting point is a deep concern for a robust science and engineering education system in the country. That concern includes both research and educational underpinnings. We are concerned by the need to continue building on the research base as we are building on the educational base.

We are deeply concerned about the situation in precollege education, and Dr. Slaughter has just given you an excellent summary. I won't add to it except to refer to what I consider the most well-documented and devastating piece of testimony I have seen on this subject. It was the testimony given by Mr. Robert B. Henderson, chairman and chief executive officer of ITEC Corp. at your field hearing, Mr. Chairman, in Massachusetts on November 24, 1981.

In paragraph after paragraph he documents the situation: Only a sixth of all high school students take junior and senior level science courses; only half of all high school students take a mathematics course after grade 10; and only 15 percent of all high school students take a course in chemistry, and only 7 percent take a course in physics. He also documents the contrasts between the situation in the United States and the situations in the Soviet Union, West Germany, and Japan. The contrasts are quite staggering.

Last spring, the National Science Board undertook an extensive piece of work directed by Dr. John Hogness to look at the priority problems in science and engineering education. In June the Board devoted a 3-day meeting to that subject in collaboration with the Director and his top staff. We agreed on a set of priorities which I think is almost inescapable.

Our first priority is for equal footing, research, and research-level education in the scientific and engineering enterprises. The two go hand in hand. Our second priority is to find a way to try to get some real leverage on the problem of precollege education in order that there may be real change in the country—some action against a situation which we see as deteriorating. Our third priority is to fund specific projects that require and deserve Federal support to target particular opportunities in science and engineering education.

It is our immediate obligation in the near term to keep science robust and to keep the fruits of science healthy in the universities. The cornerstone is a 30-year tradition in this country to fund at least federally supported research almost entirely within universities, technical institutions, and colleges in order to gain the educational benefits that come from doing so.

As you probably remember last spring, the future of the graduate fellowship program was uncertain. The presidents and faculties of the leading universities said with unanimous voice to us—and I suspect also to this committee—that those fellowships were absolutely essential to the universities' ability to continue to do the job they must do for American science. I am pleased we were able to sustain the fellowship program, and I think the administration is firmly committed to it.

There are serious concerns in this country, in particular from industry, about science and engineering education. I testified to this committee on that subject not too long ago. I sincerely believe that this country's principal advantages over the Japanese are our science and our innovation rates; both are higher than theirs. Our biggest disadvantages are the lack of focus on engineering applicable to production and the lack of motivation among engineering students for careers in manufacturing and production using the newest technology, a challenging area and one that needs attention from education, not just research.

It is not clear to me that research is an exclusively suitable vehicle for upgrading engineering education at the graduate level, particularly in those areas of engineering more related to production and to productivity than to research and development. Consequently, our second priority is to try to find some leverage on the precollege education program.

I will confess that while we looked at the kinds of data you just showed us—a correlation over time in the decline of the secondary schools' performance in science and mathematics against a decline in NSF investments in science education programs—I do not believe there is a demonstrable cause and effect relationship.

That is not to say that the schools are benefited by NSF's providing less money to science education programs. Obviously the schools are not benefited, because I believe those programs were useful and, in many cases, importantly useful to the particular subjects they touched.

But I don't believe any member of the National Science Board would be at all confident that we would solve the problem we face in precollege education simply by a continuation, or even a gradual buildup, of the same kinds of activities that NSF supported earlier.

We did not conclude on that basis that we should stop supporting the earlier programs. We did conclude that we should give a higher priority to seeking to use whatever leverage the scientific community has, whatever leadership we on the Board can exert, in focusing national attention on this issue and doing something about it.

The third priority involves specific projects. There are, of course, things we would like to be doing and a number of things we will do within the context of the NSF directorates. These primarily are not at the precollege level, but at the college and university level; they are important to education, particularly to minority and women's programs and to equipment needs.

This morning, I covered the same subject in a discussion with Secretary Bell's Commission on Excellence in Education, because I wanted to consult with them on the plans for the Board's Commission. I pointed out that the Board's plan is ambitious. And some even may say we are perhaps taking too much on ourselves to believe that we can be, or should be, the focal point for rallying the community. Nevertheless it is our objective to offer the good offices of the science and engineering community and its leadership to work collaboratively with all the major professional societies in science and engineering in this country, to work with the national associations concerned with school board activity, with science teaching, with teachers' organizations, with business organizations, to do a variety of things and to do them quickly.

I hope we will wrap up this work in 18 months. In the first 6 months, I hope we will digest the existing studies—there are about 30—all of which either now document, or very soon will document, the importance of the problem we are discussing.

I do not intend to do any further research, unless some particular area of oversight comes to our attention. The major goal of the Commission's work, through collaboration with professional scientists, engineers, teachers, and others in the country, will be to find out what can be done at the local, State, and national levels, through the scientific and engineering communities to address the issue of precollege education.

It would be presumptuous of me to tell you exactly how that is going to be done until the Commission members are appointed for so ambitious a project. But we have another thought in mind, which we reserve for future decision. I think it is a good idea at this stage, if the Commission is willing to be committed at the onset of its work: At the end of the 18 months that we expect this activity to consume, we will ask its members to agree to come back a year later and to review precisely whether what they left in place is alive and functioning.

If it is not, I for one will be prepared to agree, with those of you who are skeptics, that this Commission will not have been successful. Either the Commission will leave an active program involving a national effort to upgrade the precollege educational effort, or we will be disappointed.

I believe skepticism on this point can become a self-fulfilling prophecy. I simply plead with all of our friends and our critics to help us make this plan work and to take seriously our assertion that we want the Commission to leave an activity that will produce real action.

Funding for science education in fiscal year 1982 is miniscule. It represents an investment of NSF funds of only a little more than $1,000 per school district, and there are a good many schools in every district. That is obviously a tiny sum, but I don't believe what we were doing when we were spending $80 million was solving the problem. What we have witnessed is a national level of concern that was elevated when Sputnik was launched. A great deal of public attention was given to this serious issue; a good many things were supported by NSF, and quite a lot of the activity was very helpful.

But we have witnessed a steady decline of science, and I do not believe that the decline in NSF investment was its cause.

In my view, we need to produce the consensus that there is a workable program and an appropriate Federal role, a consensus based upon a grassroots sentiment in the school districts, the schools, and the school boards that this kind of Federal assistance is necessary. My own opinion is that once this problem is understood by the American people, that once they are prepared to get exercised about it and to go to work on it, it will be seen there are many problems needing national action, and some requiring Federal action. Such problems have to do with the expert technical content involved in science education and with the interface between the secondary schools and the colleges. We face the danger of entering an era when the declining number of college-age students will accelerate the tendency of colleges and universities to lower their entrance standards in order to attract more students. Such a policy will exacerbate the tendency of secondary schools to allow science education to fail.

Let me close with a final comment; it has to do with the NSF Director's determination to replace the Science and Engineering Education Directorate with an office. I plead with you not to view the action as replacing the directorate with a commission, for it is not so. It is, as I understand it, the replacement of a directorate with an office reporting directly to him. He consulted the Board, and the Board acknowledges not only is it an appropriate way to manage an activity with 10 persons, but also it is essential that we not kid ourselves about what we are doing.

I personally believe it would be a mistake to claim NSF has a directorate dealing with science and engineering education staffed by 10 persons. I do not believe the office represents any less commitment or concern for science education or less determination to try to play a constructive role in science education, either by the Board or by the NSF management.

[The prepared statement of Dr. Branscomb follows:]

PREPARED STATEMENT OF DR. LEWIS M. BRANSCOMB, CHAIRMAN, NATIONAL SCIENCE BOARD

Mr. Chairman and Members of the Subcommittee, I am Lewis M. Branscomb, Chairman of the National Science Board and Vice President and Chief Scientist of the IBM Corporation.

It is my pleasure to appear before you this afternoon to discuss the role played by the National Science Board in the development of the fiscal year 1983 budget for the National Science Foundation and the activities of the Board in rethinking the role of the Foundation in science and engineering education.

The fiscal year 1983 budget states that Federal responsibility in R. & D. activities relates both to Federal needs, such as defense, and to national needs, where the Federal Government helps to assure the strength of the economy and the welfare of its citizens. Two main responsibilities in this latter area are (1) providing a climate for technological innovation which in turn encourages private sector R. & D. investment, and (2) direct research support when there is substantial prospect for significant economic gain to the Nation, but where the private sector is unlikely to invest adequately.

The provision of an improved climate for private sector innovation is addressed in the Economic Recovery Tax Act of 1981, which not only seeks to increase incentives for capital investment but contains specific R. & D. incentives about which I will speak tomorrow. Hopefully, the President's National Productivity Advisory Committee, whose Subcommittee on Research, Development, and Technological Innovation I chair, will be able to come up with additional ideas that are practical and effective. Our productivity determines nothing less than the security of the Nation, the standard of living of our people, and the legacy to future generations of knowledge, facilities, and conserved natural resources. Strong and vital science and engineering capabilities are an essential element in the Administration's plan to improve economic productivity.

The second responsibility—direct support of research where the private sector may under-invest—is carried out in many agencies but especially in the programs of the National Science Foundation, where research is supported at the forefront of knowledge across all fields of science and engineering.

The National Science Board is charged by the Congress with a concern for the health of America's science and engineering capabilities. Working with the Director's executives and staff, we have spent a large fraction of our time over the past year attempting to balance priorities for NSF's research programs in the face of the very real problems caused by economic conditions and resulting budget stringencies. We are convinced that further advances in science and engineering knowledge are the cornerstone on which our military and economic security rest. Since we cannot as a country afford to pursue all promising scientific and technical avenues at once, the Board, with the Director as an active participant, has attempted to arrive at an allocation of our necessarily limited resources to maximize the return to our scientific capabilities and thereby to the Nation. Let me describe this process.

Last winter and spring, Board members had a series of formal and informal discussions with the Director and Assistant Directors about priorities in the program areas for which they are responsible. These discussions were informed by the flow of advice we get from scientists in the field—through our advisory committees, through meetings and telephone calls, and through our own participation in developments in the various fields with which each of us is conversant. Board members and Foundation staff alike consider it an important part of their jobs to be open to input from the scientific community in a variety of forms.

The Foundation and the Board must work within the context of overall budgetary policies decided by the Administration and the Congress. Last spring, as you know, the Administration requested changes in several parts of the Foundation's budget, as part of its strategy of reducing the budget in light of the Nation's economic situation. The Board's role in this case was one of assisting the Director by providing policy guidance.

In its policy paper of March 29, 1981 (which I sent to you at that time) the Board agreed that in the short term the National Science Foundation must focus the available resources on the task of contributing as much as possible to the strength of American science and technology; the quality and sufficiency of scientists and engineers educated for careers in research, development, and engineering; and maintenance of the U.S. position as a leader in international scientific and technological endeavors. Thus we put high priority on the key elements of our central mission, which we conceive to be support of science and engineering research performed in academic environments to optimize both educational and knowledge benefits from a single investment. This priority continues in the proposed fiscal year 1983 budget.

We also provided guidance for the Director in the budget reductions that became necessary during the fall. We agreed that a flat across-the-board cut would not be in the best interest of the Foundation or the science and engineering community. Instead, we asked the Director to consider the quality and amount of science for the funds invested and to give special consideration to fields which are particularly dependent on the Foundation, the effects of delays in funding, and the extent of recent upgrading and productive lifetime of installations. The Board also agreed that emphasis should continue to be given to the physical and engineering sciences and stressed the need for attention to those areas severely reduced in fiscal year 1981, particularly science education and the social and behavioral sciences. We are pleased that the final fiscal year 1982 and the proposed fiscal year 1983 budgets reflect support for graduate fellowships and the social and behavioral sciences.

The National Science Board's standing committees—Planning and Policy, Programs, and Budget—will continue to work closely with the Director to establish policies and priorities, and to set forth our best rationale and arguments for sustained Federal support of the National Science Foundation's mission.

The Administration has stressed the need to assure a healthy economy through increased capital investment and productivity, and a strong national defense. Strengthening our scientific and technological capabilities is central to both these objectives. A successful outcome of the President's economic policy would create the incentives in the private sector for an aggressive commitment by American industry to the creation of new jobs at home and economic competitiveness abroad. Creating this economic environment is a necessary condition for the revitalization of the economy. But it will also take well-trained and highly motivated scientists and engineers to translate this Nation's potential for growth into reality.

During the past year, the National Science Board considered how the Foundation might carry out its responsibility under the National Science Foundation Act to ". . . recommend and encourage . . . national policies for the promotion of . . education in the sciences" and ". . . to initiate and support . . . programs to strengthen . . . science education . . . at all levels."

The Board agreed on three appropriate priorities. Highest priority was assigned to research-level education, and this is reflected both in the continued graduate fellowship program in science and engineering education and by the research supported throughout the Foundation, with its intimate connection between graduate education and research. Secondly, the Board agreed that the Foundation should continue to play a role in identifying critical needs in science and engineering education, including needs for which it does not bear the primary responsibility. These activities may encourage other agencies, state and local governments, and private organizations to evaluate and meet those needs. Finally, the Foundation can intervene in selected high-leverage areas where significant improvement in education outcomes is possible with lmited investment. The Board asked the Director to generate a plan for implementation of this policy framework and he did so. (Both these documents were sent to you in September.)

One area where the Foundation can play a role in identifying critical needs, though others have primary responsibility, is in precollege education. Many of us in industry are concerned that the future availability of qualified scientists and engineers will be jeopardized by the decline in high school enrollments in science and mathematics, and declining quality of such instruction. Although there is an emerging consensus that something must be done to change this situation, there is less consensus about the proper role of the Federal Government, or of the Foundation. Under the circumstances, the Board concluded it must find a way to engage the Nation's scientific community in local activities to establish a stronger base of secondary school graduates with appropriate science, engineering, and math backgrounds from which to draw future generations of scientific and technical people.

At its January meeting the National Science Board approved the establishment of a Commission on Precollege Education in Mathematics, Science, and Technology. We hope to announce the Commission and its membership soon, and expect that it will have much of its work accomplished within an 18-month period. Plans for the Commission were discussed with a wide range of interested groups and individuals. The response to the idea of a commission has been enthusiastic and gratifying. There is widespread support for focusing on secondary education as a crucial element in developing scientific and mathematical skills and knowledge. We hope that the Commission and the Foundation can make a unique contribution to the Nation's education in the sciences by mobilizing those groups and individuals who seek to improve the quality of precollege math and science education.

Let me turn back to Dr. Slaughter, with your permission, so that he may comment on the Commission. I will then be happy to answer any questions that you may have, Mr. Chairman.

Mr. WALGREN. Thank you very much, Dr. Branscomb. In the time remaining with you, I would like to recognize members for questioning. Then I understand you have to leave at 1:30.

Let me first ask Mr. Brown whether you have any opening statement you would like to make or have inserted in the record at this point.

Mr. BROWN. No, Mr. Chairman, I don't. And since I was late coming in, I would prefer you recognize those who were here.

Mr. WALGREN. That is true. Mr. Weber, any opening statement?

Mr. WEBER. No opening statement, Mr. Chairman. Thank you.

Mr. WALGREN. Mr. Skeen.

Mr. SKEEN. No statement. I came here to listen to you, Mr. Walgren.

Mr. WALGREN. Perhaps I might just briefly start.

I guess basically I am troubled with the lack of emphasis that I see in this area. Dr. Branscomb, you say an effort with 10 people doesn't necessarily need an organization at the level of a full Directorate. But the effort presently has 63 people in the Directorate. To assume that we bring it down I think is going ahead of the Congress. And it concerns me that we take these actions when the Congress has provided a full program this year and may very well provide a specifically fuller program next year.

I would like to ask whether this reorganizing has any support in the Board itself.

Dr. **Branscomb**. The Board fully supports the Director's management of the priorities. Indeed, they are our joint priorities in this program. The Director is given certain personnel resources to work with, and the Foundation overall is given budgetary resources to work with. Within those resources, we jointly attempt to set priorities. So the Board is certainly in accord with these priorities and the Board certainly supports the Director's judgment because it is his call to make, not the Board's, on how he should deal with the personnel resources available to him. The Board doesn't decide or participate in deciding the allocation of personnel to the National Science Foundation. Perhaps Dr. Slaughter may speak to that issue.

Mr. **Walgren**. Perhaps. My real interest is your view as a Board member at this point. So perhaps we will come back to that with Dr. Slaughter.

But isn't it true that the Board in August of last year reemphasized the need for "a budget commensurate with the mission and program integrity as a fundamental requirement for sustaining a vital science and engineering education effort"?

Now that seems to indicate to me that the Board is not necessarily in agreement with a diminution of this function, as suggested.

Dr. **Branscomb**. The Board certainly would have preferred to keep this function strong and to see some of the program content within it. Some priorities would be required, certainly, to make sure elements of the program were continued and strengthened. What I have tried to explain is that we dealt with a set of priorities. Within those priorities, I think, the right judgments were made. I personally think it unfortunate that the Public Understanding of Science program, partially funded by Mobil on public television, is no longer with us; it was important to do and useful. I am sorry we no longer have what was a modest program at best to help science museums. But I really believe the levels of investment employed in those activities were small compared to the levels of investment that can be obtained from this Nation—from the State governments, from localities, from industry, from the private sector, and from the Federal Government—if we can get a national consensus that science education is a major problem.

Mr. **Walgren**. I certainly understand that thrust, and I just question whether in order to pursue that thrust we have to stop what we are presently doing or might be able to do.

I would like to recognize other members in the order of their appearance. Mr. Gregg?

Mr. **Gregg**. Thank you, Mr. Chairman.

Doctor, as I understand it, you listed your 3 priorities which the Board has arrived at, the first being research and research-level education; the second being the promotion of precollege education; and the third one being taking advantage of opportunities which arrive. Is that accurate?

Dr. **Branscomb**. Where I stated priorities within the educational segment, yes. My third category was educational programs.

Mr. **Gregg**. If the second priority is precollege education, there aren't any funds. There are just no funds in this budget for precollege education.

Dr. **Branscomb**. There are no funds in this budget to support programmatic activity in precollege education. But there are funds in this budget to support the work of the Commission, funds earmarked last summer before we had any inkling of what the fiscal year 1983 budget would be. What I am saying is that the Commission project was worth doing and was deserving of priority. The decision was made before we knew what the rest of the budget would be.

Mr. **Gregg**. Maybe I misunderstood your second priority. It is definitionally having the Commission go forward and then you fulfill it. But if the second priority is education of people in precollege existence, there are no funds being spent on it. Out of a $1.172 billion budget, if that is a priority and it doesn't get any funds, I guess I have to question whether the priority system is being met. I guess that is my concern.

As I understand the Commission, the basic thrust is, as you have mentioned, to develop a consensus within the Nation and then out of that consensus to drive some, generate some grassroots support which will drive the type of changes you think are necessary, that I think are necessary, and I think that most of the committee feels are necessary, and get some local support, some State support, and some national support.

Is that a correct way to define it?

Dr. **Branscomb**. And during the course of the Commission's work, we want to take advantage of the voluntary activities of scientists and engineers affiliated with national organizations to work with their local school districts in seeing what can be done immediately to be helpful. That is correct.

Mr. **Gregg**. I can understand that as a legitimate purpose. I think that is important, education of the public through this Commission, but I don't think there is any question that this Congress, or even this committee in this Congress, even on the minority side, which tends to be reasonably conservative, in fact rather conservative, even though we are placed on the left in many hearings, is either up to speed on this issue or possibly even, unusual as it may be for the Congress, a little ahead of where the rest of the folks are who are in the field.

This Congress is ready to move on this issue, I believe. I think we are concerned that dollars are being spent on the Commission that aren't necessary to educate us. That may be one of the functions of the Commission.

Second, we are concerned that if the priority is pre-college education that it is not being met. I would ask that you reconsider, if that is a priority, how you are going to meet it.

Thank you.

Mr. **Shamansky** [presiding]. Thank you, Mr. Gregg.

I would like to note for the record that Mrs. Heckler has a statement. Is that correct?

Mrs. **Heckler**. Yes. I would ask unanimous consent that it be inserted into the record.

Mr. **Shamansky**. Hearing no objection, the statement will be inserted in the record.

[The prepared statement of Mrs. Heckler follows:]

Prepared Statement of Hon. Margaret M. Heckler

Thank you, Mr. Chairman. I will say that I was pleased to see this year's NSF budget up by almost 8 percent. Considering what is going on wth other parts of the Administration's recommended budget I think we should be grateful.

My sense of gratitude is somewhat diminished, however, by the shocking situation with science and enginering education. Just after recovering from the news that there would be no funding, I learned last week that there is no more program. I am very concerned about this decision because it appears to change the mision of the Foundation which is, in part, ". . . to strengthen . . . science education at all levels . . ." (NSF Organic Act of 1950).

Now, Dr. Slaughter and I sat next to each other last Sunday at the National Governor's Association meeting on science and technology resources for the coming decade, and I know he feels the special Commission set up by the National Science Board is very important. The concept of a Commission to examine national priorities in science and engineering education is highly laudable and I think most members of this subcommittee would support it. What we are having problems with is the notion that the Commission is the only thing we should be doing.

The message from our hearings in Washington and in other parts of the country (Boston, Los Angeles, Pittsburgh, and Columbus, Ohio), and from our districts is clear: We need to do something about the state of science education in America.

We will hear in the testimony today about programs that do work extremely well for very small amounts of money and that have very significant industry support. The question in my mind then is, why can't we go ahead with the Commission and a few select programs that we know work? I am afraid that if we don't continue some funding for science education that the Commission will be looked upon as simply a token gesture and will not be taken serioulу.

Well, I would like to close by thanking Dr. Slaughter for coming up here today for these hearings. I apologize for not being able to attend Tuesday's hearing but I have reviewed your comments. I want to go on the record as a supporter of the Commission, but also as encouraging the Foundation and this subcommittee to continue the funding viable science and engineering education programs in the 1983 budget.

Thank you, Mr. Chairman.

Mr. **Lundine**. Dr. Branscomb, I am impressed with your commitment to the Commission. It reminds me, if I may digress briefly, of the story I heard about what the pig said to the chicken about bacon and eggs: "You are involved, but I am committed."

If you, as one of the most distinguished scientific people in the real world and America are committed, you have sold me. I mean, I guess I am an easy sell, but I understand your point.

The other point, though, is why, in the meantime, we don't provide any funds for science education below the college level? Aren't we really losing the possibility that some people who might meet some of those engineering needs that are so critical won't be inspired by some teacher who is really excellent at the high-school level?

Aren't we risking that we are going to skip a couple of years, and wouldn't it be wiser on the whole to provide a somewhat lower level programing with what we have been doing rather than to cut it in this interval?

Dr. **Branscomb**. There is not a unanimity of view in the Federal Government on the value of the Foundation's past activities in science education. But there is unanimity of view within the administration that the Commission can be useful.

There is no doubt in my mind that the programs being discontinued were useful and did have a specific, beneficial effect on those touched by them. What I would insist is that very few people were touched by them.

The Board's frustration, which it shares with you as individual scientists, is that we would like to be doing a great deal more and make it a great deal more effective. The opportunity to do so doesn't seem to exist.

We obviously must focus on what our first priority mission is. That is inescapable. Nobody else is going to do that for us. And we have to deal within the scope of what we are given to work with as effectively as we can. That is where we are.

Mr. **Lundine**. You don't feel that you ought to be advocates for what you have to work with? I mean, that is just sort of a given, in other words.

Dr. **Branscomb**. Certainly, I would be pleased to be an advocate for additional money in science education to sustain the operating activity.

Mr. **Lundine**. OK.

Dr. **Branscomb**. I do not believe it would be wise of the committee to shift a modest sum—modest in relation to what education requires to really make a change—from the research budget and into education. I think we can have just as much legitimate concern in this room, and this committee I think shares it, over the importance of trying to get our science and engineering moving at such a speed that we can get ahead and stay ahead of our competition.

I think that is as important as this other issue, because NSF as a Federal agency, has an almost exclusive responsibility for support of basic research in the universities. In science education, NSF has a responsibility to be helpful to State and local government.

I wouldn't want to encourage you to put $10 million, $20 million, $30 million into yet another small number of "good to have" projects in science education at the expense of the research program.

Mr. **Lundine**. Thank you.

Mr. **Walgren**. Thank you, Mr. Lundine.

Mr. Shamansky is recognized for 3 minutes.

Mr. **Shamansky**. Thank you, Mr. Chairman.

Because of the limitations on our time, therefore, we are following 3 minutes, so I am going to just get on with it, if I may, Doctor.

Frankly, I perceive your role differently than you do. Of course, you have to define it yourself. What I see you as is an apologist for your accepting these numbers, as that is all there is.

Mr. Lundine said, "Be an advocate." I frankly would have expected you, in your position, your livelihood does not depend on this, to dig in your heels and say this is wrong, but you are accepting it.

The fact that the programs we have now aren't perfect, fine. I understand that. But this Commission, in whatever it is supposed to be doing, should be supplemental. You want to put it in? Fine.

That is not an excuse to do away with what we have, imperfect though it may be.

I do distinguish between the roles these two fine gentlemen are forced to play. I say "forced to play" very deliberately. I don't see you are forced to play that role at all and I am terribly disappointed that you end up being an apologist, that you acquiesce.

"This is all we have and, therefore, we have to take it out of research." Frankly, Dr. Slaughter used the words "not unmindful and not unrecognized." I can only say that I find that unresponsive to the need.

There is a real need here. I expect you, individually, expect you and your Board to say this is wrong and we have got to make a change. That is what we are asking you to do, but you are not doing that.

Dr. **Branscomb**. Then you are not hearing me.

Mr. **Shamansky**. Well, I would like to.

Dr. **Branscomb**. We need in this country not only strong citizen support for good schools, we also need Federal support of the local activity, and we need it in appreciable magnitudes.

I said yesterday in a speech to the IEEE in California that we ought to spend three-tenths of 1 percent of the defense budget on engineering education—in addition to what we are now spending. That would just barely touch the shortfall in the production of engineers.

We ought to have in NSF a science education program bigger than it was when it was biggest, but I don't think such a program is going to help if the school districts that control the hiring of mathematics teachers and the setting of standards are inclined to prevent the full effect of this Federal investment.

We must solve both problems at once.

Mr. **Shamansky**. But you are dropping off one before you have the other.——

Dr. **Branscomb**. I am not dropping it off.

Mr. **Shamansky** [continuing]. By your failure to advocate strongly and to lead. That is what you are doing. That is what I say.

Thank you, Mr. Chairman.

Mr. **Walgren**. Thank you, Mr. Shamansky.

Mr. McCurdy, for 3 minutes.

Mr. **McCurdy**. Thank you, Mr. Chairman. I am not going to take long, but I did have one question of Dr. Branscomb.

I think it is a given in that we are communicating that we believe that where we produce those future scientists and technicians and engineers is when they are touched at that very impressionable age, grade school, junior high, and high school, and that is when you plant that seed; that there are not many lawyers or prelaw students changing over to nuclear physics, but there are usually some of the others transferring over into prelaw or law school. I am a lawyer, so I am just as guilty as anyone.

But where is the money going to come from? Where is that incentive going to arise?

We had the largest tax cut in the history of this Nation this past year. We tried to provide incentives for business. We tried to provide incentives for increasing productivity. Yet, do you see the seeds anywhere out there that are planted? Do you see a trend?

Can you give us any hope at all that business is responding to this critical need, that it is turning around? What has this administration done that you see that is providing that ramp? They always show us the charts of the ramp going this way. What is the basis for that?

Do you see any inkling of those charts that give us any indication business is going to take part, that there will be this ground swell of investment, encouragement for scientific education? Where is the basis out there? Do you see it?

Dr. **Branscomb**. I haven't heard anybody state or hope or claim that if the economy improves, the private sector will address successfully the education problem. I don't think anybody expects it. I don't think anybody has predicted it. I certainly don't expect it.

Mr. **McCurdy**. Not in the scientific community, but in the political community and political arena in which we deal, when we are talking about allocation of scarce resources and budgets, that is exactly what they talk about.

Dr. **Branscomb**. I don't believe it.

Mr. **McCurdy**. I don't believe it either. I wanted to hear you say it.

Dr. **Branscomb**. The private sector will contribute significantly at the university and graduate level in engineering and, to some extent, in science. But even at private universities, industrial support amounts to 2.4 percent of operating costs. Even if industry trebles the effort, it will still be a small effort.

The relationships will help, and the visibility will help. They won't solve the problem. Money will come but money must come basically from the school districts. That is where money comes from now.

Mr. **Walgren**. Thank you, Dr. Branscomb.

Mr. **McCurdy**. One last comment.

Under the "New Federalism" those school districts are going to have even a smaller pie to choose from and greater demands for that pie. Isn't that correct?

Dr. **Branscomb**. I am not here to advocate the "New Federalism."

Mr. **Walgren**. Thank you, Mr. McCurdy. Mr. Weber?

Mr. **Weber**. Thank you, Mr. Chairman. Three minutes doesn't let us get very deeply into a very complex subject.

The President's philosophical approach to this whole issue, as we started to discuss with Dr. Slaughter a couple days ago, is to try and sort out where the responsibilities in the areas of education and research go. We discussed a couple days ago the focus the administration puts on returning that to the State and local level. I have some short-term problems with that because of the obvious problems that those units of Government would have in picking up any of these responsibilities.

But another question the administration is trying to address obviously, and that this Comittee has to, I think, be concerned about even as we are concerned about trying to find increased funding for science, engineering education, is within the Federal Government itself. As I understand it, one of the thrusts of the administration is to try to sort out where the proper education roles of the Federal Government are served.

In the last session of Congress, as you are aware, this subcommittee and myself as an individual member supported diverting some funds from the administration's budget into the science-engineering directorate. Now we see the administration moving still further in the direction of reducing that.

I expect fully that this subcommittee and the committee will act to restore probably an even greater number of funds than we did last time to that directorate, but it does occur to me that we should look at what the other departments of Government are doing. I would look at the Department of Education particularly, and the National Institute of Education, because I understand, and it is appropriate in view of the Commission you unveiled here within the last week, that the National Commission on Excellence in Education has recently announced that they are going to be holding hearings in California, chaired by Glenn Seaborg and cohosted by Donald Kennedy, on science, mathematics, and technology education.

So it is obvious to me that the Department of Education is pursuing the subject of this very hearing in some of their activities.

I guess my question to you is: What is the educational mission, and I realize this is out of your area, but what is the mission of the National Institute of Education? How does it interrelate with the NSF and its present and projected role in science and engineering education?

Since I only have 3 minutes, I will throw all this at you at once, because I presume they won't cut off your response as quickly as they might my questions.

Is there a possibility for merging those two approaches? Whatever we may think about the appropriate Federal role in terms of science and engineering education, it doesn't make sense, I don't think, to have that role dispersed among different agencies of Government.

If the Department of Education is pursuing this through the National Institute of Education on a parallel track, it doesn't make sense to me to have this Committee funding the same basic things through the National Science Foundation. One agency or the other should take that responsibility and run with it.

I would like you to respond separately and at some length to that, if you could.

Mr. **WALGREN**. The question took exactly 3 minutes, and you may either respond, perhaps even in writing, if you would like.

Dr. **BRANSCOMB**. I would like to respond briefly and then be excused.

First, let me say the Board's Commission plans are well coordinated with those of the Commission on Excellence. As I said earlier, I met with them this morning to discuss the Board's plans with the Commission on Excellence. I don't believe we have any overlap. We have different purposes and a different focus to a degree. I welcome their hearing on March 11, and I hope to have a Board member there to testify.

On the larger issue, let me just summarize the Board's position. The National Science Foundation has a unique responsibility to try to sustain the cutting edge of basic science and engineering capability in this country. The responsibility involves the institutions that produce the professionals, the universities and the engineering schools.

The college and graduate school part of NSF's mission is an absolutely crucial and important educational mission. If it looks to you as if the National Science Board doesn't have as much enthusiasm as you would like for diverting funds from research into the support of precollege education. A local activity, it is because the Board quite honestly puts a first priority on trying to solve the educational problems at the graduate and college levels.

What I have just said is the Board's position, from the point of view of outputs useful to the country. The graduate and college level is a near-term problem. The long-term systemic problem is precollege education. I am as anguished about that problem as you are, but I believe both are education missions.

So, please, when you criticize the Board, as you are free to do and we welcome hearing it, remember this: If we are not doing what you want us to do, maybe it is because we are trying to sort out the roles of different institutions in this country for precollege and postcollege education and for research.

Mr. WALGREN. Mr. Skeen, for 3 minutes.

Mr. SKEEN. I won't take 3 minutes, Mr. Chairman. I just want to say it is amazing to me——

Mr. WALGREN. Let me just say I am afraid Dr. Branscomb has run out of time and must leave.

Mr. SKEEN. That is quite all right. I want to compliment him even when he is gone.

Mr. WALGREN. Mrs. Heckler.

Mrs. HECKLER. I want to thank Dr. Branscomb for acknowledging Robert Henderson's testimony in our Boston hearing. I also thought it was excellent.

Mr. WALGREN. I want to apologize to the other members of the committee that we did run out of time on that and return to Mr. Skeen.

Mr. SKEEN. Thank you, Mr. Chairman.

I think we have had a tremendous problem in education, particularly from the scientists' viewpoint, for a number of years, particularly starting in the elementary and secondary levels. I don't think the National Science Foundation or the Board is going to solve this problem, nor are we going to solve it here in this committee by juggling funds.

But I want to compliment them on being able to at least set the priorities on what the real problem is. It is on that college and graduate level. That is where we are hurting, and that is where we have hurt for a long time. If you are going to put funds, limited though they may be, put them where the real problem is.

I want to compliment them both on being able to set these priorities up and being tough enough to sit here and face all the criticism you might take because you are shifting and putting the funds where they are really needed. I think it is high time we got on with that kind of business.

Mr. WALGREN. Thank you, Mr. Skeen.

Let us then return, and we can build on the comments Dr. Branscomb made and raise thoughts with the other witnesses.

Dr. Slaughter, would you like to continue where we left off?

Dr. **Slaughter**. Thank you, Mr. Chairman.

I would like to finish my remarks; I will not be long. Dr. Branscomb has done an excellent job in setting the stage for discussion of the Commission and some of the important issues.

To say that I am excited about the prospects of the Commission results is to understate seriously my position. In my opinion, its importance to science education in this country cannot be overvalued.

This committee is aware of the role that the National Science Foundation has played over the years in science education. Immediately after Sputnik was launched, the Foundation's science education budget was increased to a level considered necessary by the Congress and the administration to address the shortcomings that had caused us to fall behind the Soviet Union, at least as evidenced by Sputnik.

Emphases on curriculum development, teacher training, and development of scientific manpower have been evident in NSF's budget for the ensuing 25 years. The consensus held that the Federal Government should lead in these emphases, and the National Science Foundation was expected to provide the leadership.

Without large amounts of funding, the Foundation substantially affected science education in this country at precollege, under-graduate, and graduate levels. Not only was the number of trained scientists and engineers increased significantly because of NSF initiatives, but also the general level of scientific literacy was raised by the Foundation's programs.

During the past decade, however, a lack of consensus within the respective administrations and Congresses has weakened the efforts in science education. Characteristically during the past decade, the science education budget has been reduced by the administration in power and increased by the Congress as a result of hearings similar to these held this week. That give and take, that flirting between feast and famine, that excursion on the cycle between the peaks and valleys of adequacy and inadequacy have had significant and in some ways irreparable effects upon the programs in place during those years.

That experience has affected the staff of the Foundation, the scientists doing research in science education, and the science education community, including those students who were to benefit from the programs put in place by NSF.

You will agree, I am sure, that it is difficult to manage a sound operation without systematic and sustained support from the institutions responsible for providing resources to the National Science Foundation. I think NSF has done well. I am proud of the Foundation's contribution to science education, and I think you also should be proud.

The argument that NSF programs in science education were eliminated because they lacked quality is a false and hollow one. Those programs were eliminated because we collectively have failed to think of their effectiveness in addressing the important issues that have already been outlined. We have failed to realize that optimum programs cannot result from changes based upon short-term examinations of need—changes that were not based on an overall strategy. Perhaps we at the Foundation in the past have not articulated clearly enough such a strategy or have not presented as strong an argument as we should in support of some of the science education activities. Perhaps past administrations have failed to fully comprehend and recognize the role of the Federal Government in the quality of science and mathematics instruction in this country, and perhaps past Congresses have failed to realize that their actions on behalf of the Foundation's science education budget, while well intentioned, in fact could have helped to place NSF in the untenable position it occupies today.

It is a position where a decreasing science education budget was accompanied by an ever increasing number of programs so that more than 25 separately identifiable activities, each a program addressing an important issue, and each carried out by quality scientists and teams of scientists, were supported at levels far below those necessary to make them effective.

Certainly the Foundation can be faulted for not arguing more fervently against acquisition of these programs without the accompanying resources, both human and financial, required to do them well. The result of this kind of budgetary planning and support is inevitable. Such programs are going to be found wanting in at least some respects.

It is interesting to note that the value of one of NSF's programs is evident: mathematics and science curricula developed through NSF support are widely used in various parts of the world. Japan has, in fact, used National Science Foundation curricula in many of its activities. The same curricula have been used to train scientists, engineers and production specialists who are building the Sonys, Panasonics, Datsuns, and Toyotas that you and I buy.

But we cannot continue to have an overall program in science and engineering education which lacks the coherence and focus necessary to make a serious imprint upon science and mathematics instruction in this country.

One of your members said to me recently that he would not take responsibility for the sins of his predecessors. Well, I will gladly take responsibility for the sins of omission and commission of my predecessors. For that matter, I will gladly take responsibility for the sins of omission and commission of your predecessors if you will, in fact, join me in the most important opportunity and challenge facing this Committee in its deliberations on the NSF budget. Let us put into place the structure and mechanics that will allow us to make a concerted, coherent, serious and comprehensive effort toward addressing this Nation's science and mathematics problems.

On what basis can I offer this challenge? I base it on my personal conviction that we are going to be measured not so much by what we do in fiscal year 1983 but what we leave in place by fiscal year 1993. I have said on several occasions, and I would like to repeat it for this Committee, that I believe the most important thing I will do while I have the honor and privilege of serving as the Director of the National Science Foundation is to put into place the National Science Board Commission on Pre-college Education in mathematics, science and technology, to help redirect this country's focus on scientific, mathematical and technological education.

There is a consensus throughout the length and breadth of the scientific community, there is a consensus throughout all levels of the academic environment, there is a consensus throughout the professional societies, and there is a consensus throughout business, industry and government that we must do something and we must do it differently than we have done it before.

I have the support of the administration in the requests I bring before you. I have the support of the Office of Management and Budget, the support of Dr. Keyworth, the President's Science Adviser in the Office of Science and Technology Policy, the support of Secretary Bell in the Department of Education, and the full support of the National Science Board, as evidenced by the quality of the participation I have received from the Chairman of the Board in helping to formulate and helping me to move ahead with establishing the Commission on precollege education in mathematics, science and technology.

The cost of this activity is miniscule compared to the contributions that can result. We have not included a specific line item in the fiscal year 1983 budget request because we believe that the $700,000 specified in the fiscal year 1982 plan will be adequate, and because we feel that any additional resources required will be available in the planning and evaluation budget of the STIA Directorate for fiscal year 1983. The Foundation is serious about the program. The Foundation is going to provide the support.

Mr. Chairman, I pledge my personal commitment to this program. I will be happy to come to discuss with any members of this committee, individually or collectively, the work of the Commission, the problems we encounter, the opportunities we see, and the results we can expect.

As I said on Tuesday, the Commission is not being established to conduct yet another study. It is being established to develop an action plan that will produce preliminary results at the end of 6 months, more substantive results at the end of 12 months, and a final, conclusive set of recommendations and results at the end of the 18-month anticipated life of the Commission.

The plan will identify specific responsibilities of the National Science Foundation, other Federal agencies, State governments, local school districts, private industry, private foundations, and citizens at large.

In the positions such as you and I occupy there are few material rewards. There is a great, potential reward, however, a reward received from the rare opportunity to make a far-reaching and long-lasting contribution. That is the opportunity before us now, the opportunity to put into place an activity that can be of importance to millions of young men and women and to all citizens of the country. They deserve much more than a debate over whether the National Science Foundation has a directorate for science and engineering education, or an office of scientific and engineering personnel in education, or whether the office staff should consist of 50 persons or 15 persons. They deserve more than a debate over whether this or that administration has done more or less for science education. They deserve more than debates which imply the debaters are more interested in a cause than an effect. They deserve more than programs formulated and implemented in this hearing room without sufficient deliberation to determine their effectiveness. They deserve more than a defensive posture on the part of the director of the National Science Foundation. They deserve leadership from the staff of the Foundation and the Congress in addressing the critical problems we all have identified.

I implore this committee to join me in pursuing such a reward because of the enormity of the problem we face and because the responsibility is ours. I ask you to join me in helping to support the efforts of the Commission on Pre-college Education in Mathematics, Science, and Technology because it is so important. Thank you.

[The prepared statement of Dr. Slaughter follows:]

PREPARED STATEMENT OF DR. JOHN B. SLAUGHTER, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Mr. Chairman and Members of the Committee, I am pleased to be back again for your second day of hearings on the Administration's fiscal year 1983 budget request for the Foundation. With me this afternoon are Dr. Lewis M. Branscomb, Chairman of the National Science Board, and Dr. Donald N. Langenberg, Deputy Director of the Foundation.

Today's hearings focus on science and engineering education. The Foundation's fiscal year 1983 request for science and engineering education is $15 million to be used in support of NSF graduate fellowship; I described the general assumptions which underlay this request when I presented the budget overview and program priorities for NSF as a whole on Tuesday. I won't repeat them all today except to say four things:

There is a growing, national recognition of the fact that there is a problem today in the level and quality of science and mathematics education in many of our elementary and secondary schools;

The provision of elementary and secondary education is a local responsibility;

The Foundation's priorities lie in graduate education and training as they relate to research; and

NSF can play an important catalytic role in elementary and seconday science and mathematics education.

The potential significance of this catalytic role is underlined by the recent establishment of the National Science Board Commission on Pre-College Education in Mathematics, Science and Technology. At this point. I would like to turn to Dr. Branscomb for some additional comments on the role the Board has played this year in setting the overall budget strategy for fiscal year 1983 as well as its role in reviewing science and engineering education and the establishment of this Commission.

SCIENCE AND ENGINEERING EDUCATION

I am personally excited by the opportunities presented to us with the establishment of this Commission and look forward to receiving the results of its work. I could well turn out to be one of the most significant steps we will have taken during the 1980's for the long-run improvement of precollege science and mathematics education in this country.

As the members of this Committee are well aware, the Foundation has operated a broad range of science education programs for many years. In the 1960's, we concentrated on science curriculum development, on teacher training, and on the development of scientific manpower. There was a consensus that this was an appropriate role for the Federal Government and the Foundation to play at that time. For relatively small amounts of money, we were able to have a substantial impact on precollege science education across the nation, and the number of trained scientists increased considerably.

In the 1970's, however, these efforts became more diffuse. By 1979, for example, there were 28 different programs in science and engineering education with total obligations of $80 million. Many were targeted at specific, limited problems without any very clear connection to a larger conception of the overall nature of science education. While some were, by themselves, effective, they did not always form a coherent, carefully thought out strategy for addressing a well-defined and integrated set of science education needs. Many addressed issues that were too narrow; others, while well-meaning, drained scarce resources away, leading to diffused and inefficient programs. We must avoid duplicating this situation, and I am asking for the Commission to do its work.

It is clear that the consensus which existed in the 1950's and 1960's on the nature of these needs and on the strategies to be provided had began to dissolve by the end of the 1970's. Today, most people would agree that there are problems with the state of precollege training in science and mathematics. What they cannot agree upon, however, is the exact nature and causes of the problem. Consensus evaporates almost completely when the next two questions are asked: "What remedies should be pursued?" and "What, if any, is the appropriate rôle of the federal government in providing them?"

Given this basic situation, it does not make sense for the Foundation to continue to do "business as usual" by spending scarce dollars on a group of fragmented programs whose overall effectiveness and relevance to an inadequately specified problem is unclear. Thus, this year, the Administration is limiting its request to the support of graduate fellowships while awaiting results of the work of the new NSB Commission.

This Commission can give us a truly unique opportunity to accomplish three things. First, it can focus national attention on the problems and opportunities in pre-college education in science and mathematics. Secondly, it can work with State and local officials, scientific and professional societies, representatives from industry and from academic and educational institutions to examine the total dimensions of the needs in pre-college science and mathematics education and to suggest national, and I emphasize, not necessarily Federal, strategies for addressing them. Finally, it can identify the boundaries of a new consensus on what the role of the federal government, and of the Foundation, ought to be in these strategies.

I personally wish to work with the Members of this Committee and their staffs and with other Committees and members of the Congress to solicit their views on these issues: the nature of the problems in science and education and the appropriate role for the Foundation in the future. I personally intend to work closely with the Commission to insure that its work, and reports, are completed and considered in a timely fashion.

In conclusion, I believe the Administration's request for the Foundation is a sound one, overall, based on a careful, thorough assessment of our programs and opportunities in science and engineering. I believe that there is a consensus on the importance of the scientific research base to the nation's future; there is a consensus on the appropriate federal role for monitoring and maintaining the strength of that base; there is a consensus that advances in the physical sciences and engineering will be especially significant for the long-run achievement of our national economic, productivity and defense goals. I also believe there is a consensus on the importance of scientific instrumentation and the need to broaden the personnel resource base in science and education with programs to encourage more women and minorities to pursue careers in science; there is a consensus that we need a broad base of research support for many disciplines, since we don't always know where key breakthroughs may be made. Finally, I and the National Science Board believe the NSB Commission offers an exciting opportunity for us to establish the basis for meeting the challenges of science education in the 1980's. I hope you and the Members of the Committee will share our view.

Thank you, Mr. Chairman.

I and my colleagues will be pleased to answer any questions you may have.

Mr. WALGREN. Thank you, Dr. Slaughter. I find that a very eloquent statement in view of both need and purpose.

Does Dr. Langenberg have a statement, or are you here in support?

Dr. LANGENBERG. No, sir, I do not have a statement.

Mr. WALGREN. Let me just say at the outset, and then turn to other members for questions, I am sure you can understand our concern in view of the overall direction the administration has taken. This is not just with respect to NSF but with respect to some of the other Government programs as well which many of us consider of value but about which a judgment has been made that the Federal Government is apparently of no value.

My initial suspicion I am afraid, in seeing these actions, was that that same philosophy was being applied. I think that you have dispelled that suspicion in my mind very completely.

I would have to admit that you are right in saying that we have this plethora of programs that are underfunded and, therefore, not effective. Even though they may be quality, they are not effective in addressing the scope of the problem.

I am afraid government is full of such inability to address the scope of various problems, because the problems tend to be so large. But I am concerned that we are shutting down efforts that we might agree are at least helpful to the individuals that they do reach, even though they don't reach the full scope of the problem. We can do this even as we look for a broader direction, and even perhaps the larger involvement of many sectors of our society, if we can get them involved.

Is there, in your view, a way to maintain present effort that might be recognized as, at least, effective for the people it reaches at the same time that we try to go in a larger direction?

Dr. SLAUGHTER. Mr. Chairman, you very accurately raised the dilemma. Contained in NSF's research budget are a number of activities that address some of the concerns of the committee that NSF believes are important. Each of the NSF Directorates has been charged to consider how they can provide a function for science and engineering education within their normal research activities.

So an important part of our budget is identified to reach beyond our present effort, particularly addressing issues like instrumentation; some of the problems that the committee is concerned with; increasing access for groups that historically have not been represented in science and engineering; and specific programs directed toward improving opportunities for women and minorities in science and technology.

We believe that the NSF can and will carry forward those programs at the same time we are trying to put into place a more substantive kind of mechanism, as represented by our efforts in the Commission. NSF believes that it is not meaningful to attach small amounts of funds to these big problems. It is important that we take time to sit back, to take a look at the situation, and to put something into place that will last.

I feel that very strongly. That is the direction the Board and the staff of the Foundation believe is the right one to take.

Mr. WALGREN. The committee wants to ponder that dilemma, and perhaps we can reach an understanding among ourselves of what the proper thing to do is.

I would like to recognize the members in order of their appearance. First, Mr. Gregg.

Mr. GREGG. Thank you very much, Mr. Chairman.

On this whole area of education and education dollars, I have no problem with the Commission. I think the Commission is probably a good idea.

I think the concept of getting a consensus outside of this committee might be a good idea. Grassroots support is always helpful. I doubt the Commission will generate that, but maybe it will be luckier than the other commissions which have found their documents filed away, including even such notable ones as the Kemeny Commission.

Who is going to be on the Commission, by the way? What is the character, the makeup of the Commission?

Dr. SLAUGHTER. Mr. Gregg, I wish I could give you the list of names. The National Science Board, at its meeting last week, agreed upon a set of approximately 30 persons from whom Dr. Branscomb and I will make the necessary contacts. There will be about 15 members. We are looking at scientists, nonscientists, public members, representatives of media, and others who, either from their interests or past activities, have demonstrated a commitment to this particular topic.

It will be a commission composed of people of stature that when you see their names you will automatically think, "That is the kind of person I would have put in place on such a body." I have had several discussions with individuals whose past activities have been meritorious, and with whom you could identify very strongly and be proud to associate with on this matter. I am pleased with their responses to the importance of the matter.

Mr. **Gregg**. I was just wondering if we could get a list. That would be helpful.

Dr. **Slaughter**. We will provide you with a list very shortly. I hope to have the names of the Commission members in place in about 10 days.

Mr. **Gregg**. One thing that is just so clear to me, and I think the Commission is going to conclude that it is a problem of science education, and we are talking about precollege now, one of the clear problems is money, and the fact that the science teacher in most school systems is paid the same as the math teacher.

Competition for the science teacher in the marketplace is much higher than the competition for the English teacher, who might be paid the same. As a result, the science teacher is drawn out of the high school or junior high school and goes into the private sector.

Can you agree with that as a pretty common problem of why we cannot keep the science teachers in our school systems?

Dr. **Slaughter**. As I indicated Tuesday, that is a serious problem. We don't attach enough importance to teachers in the public schools, particularly science and math teachers.

Mr. **Gregg**. There is a demand greater on science-oriented people than on English teachers.

Dr. **Slaughter**. That is correct.

Mr. **Gregg**. In fact, one of the Nobel laureates this morning mentioned it as a problem. I think the Commission is going to conclude that is a problem. I think there is a consensus in the marketplace that that is a problem. Why shouldn't this committee address that problem right now?

Dr. **Slaughter**. The Commission, I believe, will consider the problems of teachers. It will be identified as a problem. The Commission will assist us in answering the question you just raised; what can be done in a meaningful way to help address the problem—not only in the Congress but, more importantly, in the State legislatures and in the local school districts. I do not anticipate there will be any new findings.

Mr. **Gregg**. I don't either. In fact, I am fairly confident the finding is going to be there isn't enough money to pay the science teacher to keep him in the school system, and maybe the nature of the contracting we do now in our school systems inevitably means we won't have enough money to pay the science teacher considering the fact that you have this universal pay schedule where all faculty are equal.

Thus, I think we as a Congress have a responsibility to address that issue. For my part, I just don't see the need to wait for the Commission to come back on that one.

Dr. **Slaughter**. Mr. Gregg, your argument is one that is hard to find fault with. I am only concerned about the following:

We have to be careful not to take any steps in isolation; we must stop and think about the coherence of what we do. We can address a particular problem and take an action that appears, if not to solve, to make a dent in the magnitude of the problem.

That might be well and good, but I hope—and that is the reason that we believe the Commission makes a lot of sense—that we expand our vision so that we do more than address an individual problem because of the implications that particular problem might have on some other problem that we haven't stopped to think about.

We have a joint dilemma; that is, an action which might seem obvious to all of us may not in fact be in the best interests over the long run of the schools and students. I mention that as a cautionary measure.

Mr. **Gregg**. We are looking at deficits in the Federal Government of $140 billion, $170 billion, $180 billion. If you take the CBO figures, if the Congress does go into the cuts proposed by the President, they will be down to $91 billion, $82 billion, $72 billion.

Do you anticipate the NSF program is going to be expanded over just the rate of inflation? I mean, this year its increases will exceed the rate of inflation by about 2.7 percent or 2 percent, but do you expect you are going to see an expansion of program dollars in NSF funding over the next few years?

Dr. **Slaughter**. I expect the trend in our current budget will be followed in the future. I am not sanguine that there will be tremendous increases in the NSF budget.

On the other hand, I am optimistic enough to believe that the value of our investments in scientific research, both basic and applied, is well enough understood by the administration and the Congress, that the NSF budget will continue to show some real growth.

Mr. **Gregg**. Let's say that the Commission comes back and suggests you spend money on something, which is a pretty good likelihood, and we can anticipate with our continued deficit that logically your program isn't going to be expanded dramatically.

If you are going to respond to the Commission, and as your testimony certainly is intense and personal, and I thought it was great, the intensity of that commitment, you are going to have to take some money from somewhere to do it, aren't you?

Dr. **Slaughter**. I expect there will be as great a likelihood that the Commission will come back and say that the Department of Defense or the Department of Commerce should spend some money. I don't see the Commission's purpose solely to define the National Science Foundation budget.

Dr. **Langenberg**. Mr. Gregg, your questions have raised a point that is important to make. It is a conclusion that comes from 20 months or so of discussing this issue in all kinds of forums, groups involving academics, nonacademics, educators, noneducators, laymen, scientists, nonscientists, and private citizens.

The subject of education in general and the subject of science education in particular seems to come up with incredible frequency, and a conclusion that I draw from that can be described in the terms Dr. Slaughter used in his statement: Lack of consensus.

There appears to be an almost complete consensus among all the persons I talk to that education is important, critically important, to the future of this country. I know of no one who would disagree with that statement. There is perhaps a little bit less of a consensus that science education is important. In the minds of some people, in a world in which some high school graduates are functionally illiterate in the language of the land, science may seem somewhat less important.

But where the consensus begins to fail is when you ask, "All right, let us assume that science education is important. Now, what must we do to assure that our young people get the best possible science education? What must we do precisely? Who should do it? Who is responsible both for performance and for finding the resources to support that performance?"

At that point, the consensus, in my experience, disappears almost entirely. I would say, and I may be presumptuous, that if this subcommittee has a consensus on those questions, it must be the only group of comparable size in the Nation that has such a consensus.

I think the lack of consensus is one of our fundamental problems. We all agree that there is a problem in education. We almost all agree that there is a serious national problem in science education. Now, let's agree on what to do about it and who should do what.

I don't believe that consensus is there. I think it is the key problem in science education. It is even more important than the problem of limitations on resources, whether they be Federal resources, State resources, or private resources. We must have that consensus before we can move ahead.

It seems to me that the critical function of this Commission is to make an attempt at a difficult problem, and that is to discern and, if necessary, perhaps to help develop a national consensus on those questions.

Mr. **Gregg**. Well, I would agree that there probably isn't a consensus on the overall issue of science education, but I think there is a consensus on the fact that we have a problem maintaining science teachers simply on the dollar level, the salary problem in the teaching of science in the school systems.

I think there is consensus in that within the education people I talk to, even within the National Education Association, which happens to take one of the views that doesn't allow for bifurcation of salary; that you can't keep the science teacher because they can make more in the private sector. So there is maybe just a small part, but it is an area on which I think there is consensus which I think the Congress can address.

Thank you.

Mr. **Brown** [presiding]. May I just remind all the members that we have two other panels, and I hope that when we come to the last panel there will be someone here besides the chairman?

I would like to recognize next Mr. Lundine.

Mr. **Lundine**. Thank you, Mr. Chairman. I hear you.

Dr. Slaughter, you are very impressive. I am indeed impressed with your commitment to a concerted effort, as you called it, in this area, but I guess the problem I have is why should we throw out all science education programs, both the good and the bad, before you develop a different program?

Dr. **Slaughter**. Mr. Lundine, I think a part of the dilemma is that I don't know of any bad programs in what NSF did. There were too many programs. That is a point I tried to make, and I defy us to bring together the collective wisdom to decide what are the 3, 4, or 5 most important programs that are needed right now. This is part of the problem.

I think we have suffered from an ever-growing mountain of needs and inadequate resources to address them all. It is difficult for us to defend all of the programs.

Mr. **Lundine**. You know, there was a fellow who was around this town a few years ago who did admittedly leave in disgrace, but I think he left after him a very important philosophy, which was if it ain't broke, don't fix it. It seems as though you have a different one, that it is broke, so therefore throw it out before we figure out how to fix it.

If I understand it correctly, you are saying there are too many programs. All right. Let's concede that. But the answer to that is to do away with all of them and then study it, and have a period of time go by during which nothing happens, and then we will come up with a concerted effort.

I came here openminded. I am becoming convinced maybe we do need what you describe as a concerted effort toward a different program. But why dismiss what is going on just because you can indict it? Certainly you can indict it, that there are maybe too many programs. Why throw it out in the meantime?

Dr. **Slaughter**. We haven't thrown it out. Perhaps you were not in the room at the time—I indicated that some of the programs for science and engineering education are, in fact, being accomplished within the research directorates.

Mr. **Lundine**. I understand.

Dr. **Slaughter**. Particularly, those programs dealing with instrumentation and the kinds of interfaces that our colleges and universities can have upon education, are examples of such programs within our research directorates.

At the same time, I believe the period we are discussing now is not for the purpose of studying the problem. Rather, it is to develop this kind of consensus that both Mr. Gregg and Dr. Langenberg have just discussed. The fiscal year 1983 can be meaningfully spent supporting those programs we have and putting together some actions that can address these concerns in fiscal year 1984.

Mr. **Lundine**. I don't know if we are trying. I don't know if we are getting our point across. But I think there is a consensus at least here on both sides of the aisle, and I think it is shared by you and Dr. Branscomb and others, that there is a very serious problem and that we ought not to allow additional time to slip by without addressing that. No?

Dr. **Slaughter**. Yes; that is shared.

Mr. **Lundine**. And you honestly believe that you recommend this budget, commend it to us, even though five-sixths of the staff attention and virtually all of the specific programs addressed to science education have no inclusion in that budget?

Dr. **Slaughter**. Mr. Lundine, you haven't answered the very important question that I would direct to you. That is, "how do you identify the resources to do those things that may be in the consensus that you have mentioned?"

Dr. Branscomb said, and I am in full support, that our research program is a valuable one that can not afford to be utilized to support other kinds of programs. Certainly that is true at the level of support necessary to make a significant contribution to the science education programs we are discussing today.

I don't see any possibility for us to be talking about significant increases to the Foundation's budget in fiscal year 1983 that would allow us to do the minimum level of important research and graduate-level activities that have to be accomplished if we are going to maintain our security and productivity capabilities in the country, and to address the other matters also.

Mr. **Lundine**. Well, I would love to try to answer your question, but the chairman wouldn't like it. I see him poising the gavel to come down already.

With all due respect, sir, I do believe that is for us to decide. Last year we didn't agree with some of the administration's recommendations, and lo and behold, they came around. So I hope that we will decide.

Mr. **Brown**. Mr. Shamansky.

Mr. **Shamansky**. Dr. Slaughter, I want to begin by observing that the assumption that the Commission is going to come up with the consensus is hopeful, charming and I believe naive. We haven't reached a consensus so far. It is only a group of human beings. Someone has given some thought to it so far.

Now what we are all trying to say to you is, you are throwing the baby out with the bath water. You say here that you have got the money in the current budget, $700,000. Spend it. You can do it. Do it. But don't use that as a pretext for dismembering that which is at least working, albeit imperfectly.

Now you cited at those who agree with this, the administration, the Office of Management and Budget, which at this point, looking back at their record last year, I can characterize as a bunch of juvenile cretins. Dr. Keyworth and Mr. Bell, who are folks in charge of the henhouse, you are citing them as authority for doing this kind of a thing. Our responsibility is to make a judgment and say those numbers are inadequate.

You were presented with these numbers, and all I find you doing is acquiescing. I am begging you, and Dr. Branscomb is in a different position, his job doesn't depend on it, but I am simply saying, this is, I find, disappointing on your part.

Now, first of all, you are not just saying we are going to do this new study. You are now using this study to cover the fact that you are going to dismantle the positions. We can put money back in, if you need it, on a supplemental. But you are going to do away with the positions. That is much more difficult to put back in. But the idea that there is no value, albeit they are imperfect, is not, as far as I am concerned, any basis whatever for saying that we go to this study, which will work miracles, and then do away with that which is at least in place, albeit imperfect.

Now killing the existing programs is not a prerequisite for initiating what you are proposing here. I would say to you with respect to this Commission, "Go get them, Tiger." I think that is terrific. But the idea that you are posing it as this or that, I see no intellectual connection. I don't see the connection between the two. All you are doing is cleaning up with what they are leaving you. They are saying, "Here, that's it. You do with it what you want."

If you want to protect research, fine. But then don't use that as a pretext for wiping this out and justifying it.

Dr. **SLAUGHTER**. Are you finished?

Mr. Shamansky, I am disappointed, myself, that I have not been able to speak more clearly or forcefully and certainly not to be able to make the point that I, for one, would not sit here and try to recommend another study. I have recommended an action plan. I find those vastly different. I am sorry that I have not convinced you that I mean that.

I think that in the position I find myself, it would be very easy to take an approach of jousting at windmills or offering up sacrificial lambs this year. But I have determined that the National Science Foundation's responsibilities are too great. It is more important for us to use this period of time to do some creative thinking.

I think we have done that. I still stand behind the argument that what we want to put into place is solid.

Let me make one other point. I am not quoting Dr. Keyworth, OMB, or Dr. Bell as authority for what the National Science Foundation does. The authority for the action that we are proposing is vested in us by statute, which I believe the committee has the principle role in establishing and maintaining. That authority is the one that we are calling on for the establishment of the Commission.

I believe it is right for us to do so. Unless this committee deigns that it is not the correct action for us today, we will proceed, hopefully, with your full support and concurrence.

Mr. **SHAMANSKY**. Well, I have to respond in this way. I want you to think creatively. But with all due respect, I think I do, too. I think my motives are as pure as yours. I am not impugning your motives. I am saying that to suggest that what you are suggesting, that to want to do in this thing is somehow solid, and that which we have here is somehow rather ephemeral. You want to do a study? Marvelous. Do it. But what you are doing is you are using that program that you want to set up and you have the money for, some way or another, as justification for doing away with this without really convincing at least this member that there is no value here.

On the one hand you say, oh, yes, they are good, and for the people they reach it is OK. We haven't reached enough people. That is right. But until you can show me cost effectively that there is nothing here, and you haven't studied that. See what you haven't done is shown definitely that what we have has no value by any stretch of the imgination. But you are prepared to throw it out.

Now again, Mr. Chairman, before you hit the gavel, I stop.

Mr. **Brown**. Mr. Weber.

Mr. **Weber**. Thank you, Mr. Chairman.

Are we under the 5-minute rule?

Mr. **Brown**. I am afraid under the circumstances I will have to enforce time.

Mr. **Weber**. I understand.

Dr. Slaughter, I want to add my voice to those who say they appreciate very much your statement. I thought it was an excellent statement. I am sorry I have to take a minute to defend the job that you are doing, but I just want to say that I think that although I may not agree with every item in the administration's budget necessarily, I do not believe the budget presented by the administration or views that you have expressed here are lacking. I commend you for it. I think you are doing a very fine job and in a very difficult time.

I would point out to members of the committee as well that last year when Dr. Slaughter was before us, we heard particularly from the majority of the demise of the National Science Foundation.

Now after the Foundation is being presented with a budget which, although lean, does increase at least somewhat above the inflation rate, we don't hear a whole lot about that.

So now it is the priorities within that budget that are subject to charges of such gross irresponsibility and intellectual deceitfulness. I don't agree with all the priorities expressed in that budget, but I think it is an honest budget. I think it is a good, straightforward attempt to deal with some problems. I also think that the administration and your testimony have highlighted the very real difficulty that we face within the Federal Government in terms of the priorities and dispersion of programs throughout the Federal bureaucracy.

It is very interesting to me because I was not one who initially supported the Department of Education. But the advocates of that Department in the first place, who were mainly from the other side of the aisle, argued so forcefully that we had to have this because these educational programs are scattered throughout the bureaucracy, and there is no ability to focus our attention on the real problems of education.

Now we find many of those same people arguing that this is a different issue and we shouldn't be concerned about that. I guess I would like to focus just a little bit on that and ask you basically the same question I asked Dr. Banscomb. I realize that you are limited by your role in how you can address it, but it seems to me we ought to focus on what is happening within the National Institutes for Education and what you are proposing to do within the National Science Foundation.

Can you respond as generally or specifically as you can to that?

Dr. **Slaughter**. Yes. First, Mr. Chairman, I would hope you would give Mr. Weber all the time he would like.

Mr. **Brown**. We will try to be fair, Dr. Slaughter.

Dr. **Slaughter**. Mr. Weber, the issues related to Department of Education and their interface with the Foundation are not clear. The current plans of the Administration to disestablish the Department of Education do create some impact on our budget. There are two programs that were part of the Foundation. One, a program oriented toward improvement of minority institutions, is the Minority Institutions Science Improvement program. The other is a program focusing on kindergarten through fourth-grade teacher preparation program.

Both of these programs had been a part of our science education directorate and were transferred to the Department of Education at the time it was established.

The current thinking of the administration in developing an education foundation would be to transfer back to NSF the Minority Institution Science Improvement program. Our budget shows a fiscal year 1983 request of $3.3 million figure for that program.

There are some joint activities we have entered into with the Department of Education. The study done in 1980 on science and engineering education for the eighties and beyond was jointly assigned to the Department of Education and National Science Foundation. We collaborated in preparing that study, which is the one that is still most often referred to in terms of the statistics that many people quote concerning the problems in science education.

There are also some joint programs between the Foundation and the National Institute of Education. In particular, the program having to do with mathematics education, the level of achievement of mathematics instruction, addressing some of the problems Mr. Gregg and others have pointed out about teachers.

Those programs have been moving along jointly. My thought would be that if the plans continue for disestablishing the Department of Education, that we would find ourselves being principally responsible for carrying on that level of activity.

Mr. **Weber**. Thank you. Because I realize that despite your entreaties I may be cut off at some point, I want to ask this one final question.

I know you, as other agency heads, face a very difficult problem in terms of dealing with the personnel who are displaced as a result of either budget reductions or changes in budget priorities. I would suspect that in your case that is a particularly troubling problem because you have a very highly skilled level of personnel.

I would like to know how you are dealing with those problems, what is happening to those personnel. Can you describe for us your efforts in that area?

Dr. **Slaughter**. Yes. We have taken that matter seriously at the Foundation. We determined very early that the members of the staff in the Science and Engineering Education Directorate would be affected by the draw down on the Foundation staffing. It is important for this committee to understand that the Foundation's overall staffing levels are determined as a part of an overall administration review. We were faced with an overall reduction at the Foundation in the neighborhood of 5 percent of our staff. That represents a significant share of the Foundation's overall staffing of around 1,200.

We determined that there were people qualified both because of their scientific backgrounds and because of their experience in the administrative and clerical areas that could be meaningfully utilized elsewhere in the Foundation. I am very proud of the fact that of the 67 or so persons in that Directorate, we have already found positions for all but about 10 of those.

And that has been done either by outplacement or by finding positions within the Foundation that they could move to.

Mr. **Weber**. Have any of those people moved to the Department of Education?

Dr. **Slaughter**. No, not to the Department of Education.

Mr. **Brown**. The time of the gentleman has expired.

Mrs. Heckler.

Mrs. **Heckler**. Thank you, Mr. Chairman.

I want to congratulate you, Dr. Slaughter, on a very fine statement. As one who participated with you and Congressman Brown at the National Governors Conference Task Force on High Technology, it is quite apparent to me from the really expert participants from the private sector and the public sector that in terms of math, science, and technology education, we are crawling toward the crisis instead of leaping to meet the challenge. And we cannot make the quantum change with the funding level that we are presently dealing with.

I think the Commission, perhaps, is the only potential vehicle for creating an awareness in the country of the dimensions of the problem and the potential solution. I have great faith and a sense of hope that possibly, if this Commission is composed of really knowledgeable, effective communicators, that we can spread the message fairly quickly and get into motion the kind of multilevel changes in education at every school district, in every school district and every level, that will make a difference overall.

Obviously from your statement it is quite clear that there are monetary constraints in what you are suggesting. There are boundaries to what you can implore this committee to do.

I have a sense of optimism on the results, providing that there are good followup efforts to take advantage of what the Commission will propose, and I think the emphasis and focus the Commission will create.

Now what is the time frame that you are considering for this Commission, and what followup do you envision?

Dr. **Slaughter**. That is a very good question, Mrs. Heckler. The time frame for the life of the Commission is 18 months. We anticipate it will have output at 6 months, 12 months, and 18 months.

As Dr. Branscomb said, we are going to ask the Commissioners to come back a year later and look at what they have recommended and what we have done with those programs. The National Science Foundation will have a staff working concomitantly with the Commission. It will be a full-time staff in the neighborhood of seven to nine persons. I have not decided on the precise number at this time; however, the Commission staff will be carrying out the kind of action steps that emanate from the Commission's deliberations, seeing to it that the communication that you point out—the information transfer which is so vital in making this a success and carrying the message out to all parts of the country—takes place.

The infrastructure of the Foundation throughout all the research directorates will be a part of that effort because we believe it is something that is a Foundation-wide responsibility. The followup will be handled through my office.

This is an important matter; I will be the person as knowledgeable as any about what is being accomplished.

Mrs. HECKLER. Do you expect, Dr. Slaughter, that some of the Commission members could be engaged in the followup activities? Because it seems to me continuation of their advocacy is a very key factor.

Dr. SLAUGHTER. Yes.

Mrs. HECKLER. We began the campaign on physical fitness, I don't think we quite expected to see as many joggers as one now sees in Washington at all hours of the day. But jogging took off and now is almost an American mania, and a very healthy one. I would like to see this emphasis on a new direction in education, math, science, and technology emphasis particularly, taking that kind of a grassroots, main street complexion. Can you see this happening? Will these people make that kind of a commitment?

Dr. SLAUGHTER. Yes, I believe they will. I think your point is a very good one. In fact, I smiled when you made the analogy between the President's Council on Physical Fitness because that is precisely the analogy we have used in saying we want our Commission to have that kind of an impact. No one knew at the time the President's Council on Physical Fitness was established that it would be as omnipresent as it turned out to be. But that is precisely the kind of model we are using in our thinking about the potential impact of the Science Commission.

Mrs. HECKLER. You state in your testimony that you expect the women and minorities program would be preserved? Even under the current budget proposals? Could you elaborate on that?

Dr. SLAUGHTER. Those figures are increased in fiscal year 1983, as a matter of fact. We have a new program for visiting professorships in women that will be expanded five-fold in fiscal year 1983 from the fiscal year 1982 figures at believe a level of $2½ million. We have two programs oriented toward minorities. One is individually oriented, and assists young minority scientists get a start in scientific research. The other program is oriented toward institutions.

In part, the institutional program is a direct response to the President's Executive order for the historically black colleges and universities. We have taken a very aggressive stance in the Foundation in trying to extend that influence with the other agencies in the Government that have a scientific and research and development funding responsibility.

Mrs. HECKLER. I understand and appreciate that. I would like to say Mr. Chairman, for the good of the order, I would encourage my colleagues to cosponsor the legislation that was actually conceived by Steven Jobs of Apple Computer and has prompted him to make a generous contribution of equipment to local schools. This is a proposal in the Tax Code which would allow for a tax credit for the donation of technological equipment to local schools.

I think if we want to have this Commission get off the ground, the best way to do it is give them the legal incentive to find it possible to not only have a new focus on science and technology, but to support the tax credit bill which gives the local schools the equipment it needs to make the program fully effective.

Thank you, Mr. Chairman.

Mr. WALGREN. Let me be the first to cosponsor that.

Mr. Dymally.

Mr. **Dymally**. Let me be the second to cosponsor that bill, Mrs. Heckler.

Mr. Chairman, as you know, I had the privilege of serving with the President in California and at the time he was very skeptical about the notion of this Democratic Party institution of studying the issues. Now I see the administration has embarked on studying every American issue to death, so I must with some humor observe the fact that every major issue that comes up now, the administration wants to study it.

My questions were covered by Mr. Lundine and Mr. Shamansky so I don't have anything further to add except to tell the Director that I share the concern that we need to try to preserve the directorate while we study new ways of solving that program.

Mr. **Walgren**. Thank you, Mr. Dymally.

Does anyone else wish further rebuttal before we excuse these witnesses?

If not, I want to thank both of you gentlemen for your excellent defense under trying circumstances of the situation you are in here.

Dr. **Slaughter**. May I correct a number I gave Mrs. Heckler by mistake. That visiting professorship for women is doubling in fiscal year 1983. I made a mistake in terms of numbers. It is up from a half million dollars in fiscal year 1982 to a million in fiscal year 1983.

Mrs. **Heckler**. Better a small improvement than none at all.

Dr. **Slaughter**. Thank you.

Mr. **Walgren**. Our next panel is composed of the following distinguished witnesses: Dr. James Rutherford representing the AAAS; Robert Finnell, executive director of the MESA program, mathematics, engineering and science achievement from the University of California at Berkeley; Nancy Kreinberg, director of math and science education for women from Lawrence Hall of Science, Berkeley; and Dr. Robert Glaser, president of the National Academy of Education, University of Pittsburgh.

[The biographical sketch of Dr. James Rutherford follows:]

F. James Rutherford

Currently Chief Education Officer of the American Association for the Advancement of Science, James Rutherford served as Assistant Director of Science Education of the National Science Foundation before becoming the first Assistant Secretary for Research and Improvement in the newly created Department of Education. Prior to his federal appointments, Dr. Rutherford was professor of science education, head of the division of education and director of Project City Science at New York University, where he went after serving on the faculty of Harvard University and directing Harvard Project Physics. He has also been a high school science teacher, written and spoken extensively on issues in science education and served as a consultant on science education in many countries.

STATEMENT OF DR. JAMES RUTHERFORD, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE; ROBERT FINNELL, EXECUTIVE DIRECTOR, MATHEMATICS, ENGINEERING AND SCIENCE ACHIEVEMENT [MESA], UNIVERSITY OF CALIFORNIA, BERKELEY; NANCY KREINBERG, DIRECTOR, MATH AND SCIENCE EDUCATION FOR WOMEN, LAWRENCE HALL OF SCIENCE, BERKELEY, AND DR. ROBERT GLASER, PRESIDENT, NATIONAL ACADEMY OF EDUCATION, UNIVERSITY OF PITTSBURGH

Dr. **Rutherford**. I want to thank you for inviting me to testify again, but I must say at the outset that I take no pleasure in it this year. I say that because I am going to have to take a different view from my good colleagues of what we ought to be doing about science education.

To begin with, I must say that we may be talking here about the wrong problem at the wrong time.

Given the dimensions of the problem in the United States, in scientific, mathematical, and technical education, to find ourselves in a debate on whether or not the National Science Foundation should have some funds for supporting science education is just strange. Rather, we should be talking about what the Federal Government, the National Science Foundation in partnership with the States, the local authorities, and the private sector are going to do so we can stay a first-rate nation.

Today I would like to talk with you on three matters: the Commission idea, H.R. 5254, and some actions that Congress might take, since it is fairly clear at this point that the administration is not prepared to recommend actions.

A great deal has been said about the Commission that I find puzzling. I find it difficult to understand how we can say that, yes, there is a problem, so we must have a Commission to get consensus on the problem and take some kind of grassroots action. While we are figuring out how to do that, we will stop the enterprise that by the admission of NSF officers and others has had positive effects.

I don't mind the idea of establishing a Commission. I think studies are useful, but Mr. Slaughter has very eloquently pointed out that the trouble in the past has been that there was a lack of coherence, a lack of a strategy in how to put the NSF programs together.

It really wasn't the fact there were too many programs. One can sort those however you choose. There have been any number of plans submitted from time to time to provide order to that. It was the fact that certain programs were underfunded while others were overfunded and the connections weren't proper.

So then why not a Commission or a committee that will simply lay out the strategies and the organization for the National Science Foundation? Why must there be a Commission that will try to tell the States—who didn't ask for the advice—and the local school districts—who didn't ask for the advice—and others what they ought to be doing as opposed to a partnership approach.

Part of my objection to the Commission is the tone of it rather than that a study be made.

If, in fact, the purpose is to get the scientific community involved, then I think this committee should know—as the NSF should know—that the AAAS, the National Research Council of the Academy, IEEE, the American Physical Society, the American Chemical Society are all generating programs to do just that.

What these organizations need is support from the National Science Foundation and they would go ahead with the programs on a sustained level, not for 18 months, but for as long as necessary.

On the question of consensus and the need for a Commission, let me suggest that there has long been a consensus on what the problems are. We simply know—we have known for a long time. There is a whole set of problems. There are not one or two problems; there are many of them. I think we have a very good consensus on what some of the solutions are, but not all.

For example, I know of no superintendent, school official, or university person who does not agree with the teachers that teachers need immediately more training in their disciplines. They haven't had it for nearly a decade.

The only lack of consensus is on who is going to pay for that kind of training.

On the other hand, there is the problem that our universities are not producing quality science and mathematics teachers. When the entire State of Minnesota, for example, can produce only one physics teacher in 2 years, then you know you have a problem, but you also have a problem that you are not sure you have a solution for.

So I think one has to look at these differently.

I have talked to superintendents. I have talked to people in industry. I have talked to people in the schools. They want help.

Take the case of the museums. It was mentioned that we have to get more of them involved in the action. They are very important. They are losing money locally. The States are withdrawing support, and now the Federal Government is withdrawing its support at the same time it intends to create a Commission to go out and talk to them about something.

I hope that the Commission is as Dr. Slaughter says. I think it can do some good if it will concentrate on the strategic questions of how to bring our mutual resources to bear on a complicated problem and include the NSF. I do not think any solution without NSF will work. People have mentioned the Defense Department, the Energy Department, and other places that might support science education. Those are mission agencies. Their notion of education is oftentimes a little different from the NSF's, and it changes from administration to administration and properly so.

The National Science Foundation's mission is the generation of scientific knowledge and its concurrent responsibility is to see that the schools help our children and citizens understand that knowledge and how to use it.

Let me turn then to talk about the Engineering and Science Manpower Act that has been proposed by Mr. Fuqua and others.

The thing that is most attractive about this is that it is a plan of action. It says let's not study, let's not wait, let's do some things now. The kinds of things that I think it lists doing are clearly needed. There have to be ways of coordinating action, bringing tc bear our resources. We have to reach out and continue to work at the various levels where we know there are problems.

There is a question of focus. I think the bill could stand some pulling in. The bill perhaps needs to indicate which of all of the science and manpower issues, it wishes to address. I would also like to see in the bill some statement about State connections.

Let me point out that recently I have had the opportunity in two States to meet with groups that are trying to build State consortia of industrialists, scientists, and educators to attack the problem, and they would like to have a link with the Federal Government. I think the bill might include some provisions for promoting such partership.

Finally, let me just make an offer to this committee on behalf of that bill. The American Association for the Advancement of Science and the National Research Council of the National Academy of Sciences would be pleased to convene a group of people to examine the bill in some detail with reference to how it might be strengthened.

Finally, let me turn to the question of action. I think I made it clear that I feel that action is what is needed. Something needs to be done. A study that goes on 18 months or 2 years, or, as the original document I have says, 33 months, will run into an election year. Bills will have to be generated. New personnel for the Foundation will have to be located, because people are not there anymore and there is no vehicle for starting up fast. We are talking about 4 or 5 years. I don't think the Nation can afford that length of time.

May I suggest, therefore, that while I think Congress itself cannot generate a strategic conceptual plan of action, what it can do is insist that certain programs that address known problems and needs and that are known to work be funded this year, this next year. Let me suggest just two or three.

We know we are not going to have better science teaching if we haven't better prepared science teachers. The data that the National Science Teachers Association is presenting to you will document the terrible state of affairs with regard to the training of our science and mathematics teachers. A half dozen different ways have been developed over 30 years for federally sponsored programs to rapidly increase the scientific knowledge of these teachers. They need that help. We ought to do it for the high school, junior high school, and undergraduate teachers.

Second, the teachers need some support. We know we are moving into a technological age in which computers and satellite systems and television can make a difference and magnify the ability of the teacher. We need a plan of action to get that started.

Then let me mention children. If we are going to have scientists in the year 2000, we want people to become interested in science. There are some programs that work perfectly well at motivating young people. The television series 3-2-1 Contact has had very strong acceptance. It is getting to young people all over this country for a few cents each, helping them to begin to understand something about science. To let that program disappear for a few years while we study things seems to me incomprehensible.

Similarly, we have for a quarter of a century known how to identify talented high school students and get them into summer programs in our universities, our university laboratories, our industrial laboratories and our Government laboratories; and furthermore, we know how to attract and identify minority students and girls to participate in such programs. Why we would stop these programs—ignore a generation of bright high school students—while we figure things out, also is beyond me.

Now I mention science centers because they were mentioned earlier. They are hurting. Young people, early adolescents, in particular, often get their first interest in science in our science centers and museums. Almost all of their sources of revenue, including Federal revenue, are now drying up. That seems to me to be a loss that is neither necessary nor desirable.

Let me conclude, these remarks therefore, by saying I support a study. I think the NSF might look at the grassroots. The NSF should learn and the Government learn from the grassroots educators how to help those people to deal with their problems.

In the meantime, I would like to recommend to you that you really consider changing the budget proposals and insisting that certain kinds of programs be continued in the science and engineering directorate of the National Science Foundation.

Thank you, sir.

[The prepared statement of Mr. Rutherford follows:]

PREPARED STATEMENT OF F. JAMES RUTHERFORD, CHIEF EDUCATION OFFICER, OFFICE OF SCIENCE AND TECHNOLOGY EDUCATION, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE CRISIS IN SCIENCE EDUCATION: A BRIEF SUMMARY

Increasingly there has been talk of a developing crisis in science education. Both the specialized literature and the popular press have been pointing to it sporadically during the last 5 years, and in 1979 the President of the United States required the Director of the National Science Foundation and the Secretary of Education to submit to him a joint report on it. Congressional concerns have been expressed in hearings, scientists have spoken out in editorials and conferences, and in general there seems to be a growing awareness that there is something drastically and dangerously wrong with science education in America.

But what is it that's wrong? Just what is the crisis in science education? My own reading of the literature coupled with my many discussions in recent months with scientists, engineers, educators, publishers, industrialists, business executives and others has confirmed what I already believed, namely that the U.S. science education enterprise is faltering badly when it comes to preparing citizens for life in a culture that is increasingly scientific and technological. As the report to the President asserts after a thorough review of science education across the nation: our ability to attract and properly train sufficient scientists and engineers of the highest quality is fraying; the business, political, educational and other non-scientist leaders in the nation are not receiving an education in science and mathematics appropriate to the times, to the kinds of problems and issues they face in their everyday work; our security and our economic health are being undermined by our failure to produce high school graduates who are well enough educated in science and mathematics to meet the needs of the armed forces and the industrial and public service enterprises; and the gap between the public understanding of science and technology and requirements of citizenship in a participatory democracy is wide and growing. Whether one looks at performance or at structure, science education in this country is not serving sufficiently well either the national interest or the individual well-being of our citizens, and it appears to be deteriorating. That, briefly put, is the crisis in science education. It might be possible to be sanguine about the weaknesses in science education in the United States were it not for two facts:

Far from atacking this national problem with renewed commitment and intensity, the federal government is retreating and appears to be about to abandon altogether any serious effort to help upgrade the quality of American science education. Given their own budgetary strains individual states are reducing their support of science education also, and this trend is likely to become more pronounced as the states take up more of the burden, formerly federal, of support for education of the disadvantaged.

In stark contrast to our lassitude our chief economic and military competitors in the world are actually strengthening science and mathematics education and extending it to all of their citizens.

Most reports dealing with the decline of science education present a mixture of statements that blend symptoms (e.g., declining test scores, decline in science course enrollments, etc.) which causes (e.g., poorly prepared and misassigned teachers, inappropriate science courses, too few science requirements for graduation academic-industrial pay differentials for PH.D level engineers, etc.). But such views are important because they indicate what the options are for trying to design practical remedies. In what follows I have tried to distill from the literature and my interviews what are generally held to be the reasons for our current difficulty.

STUDENTS

Are less likely than in previous times to elect to take chemistry, physics and advanced mathematics in high school. Are not, furthermore, required to take much science at any level if they do not intend to go into a science-related field. A recent study of state-legislated curricula shows that only half of the states require at least one science course before high school graduation, five require two or more courses, and the rest mandate none. In seven states the mandated course is physiology, and in five states health and hygiene courses satisfy the science requirement.

Have been captured by television. As a result they suffer from reduced attention span, undeveloped reading and writing skills, and negative attitudes toward teachers of demanding subjects.

Lack motivation to study science and mathematics. This comes about because the school climate is unfavorable to the pursuit of excellence, because students know they can get into college without those courses, because they do not perceive the content of those courses to suit their current (and individualistic) needs, because (according to at least one study) their parents do not seem to be very concerned about their science education, and because of poor career counseling.

TEACHERS

Are poorly prepared to begin with. Their subject matter competence is weak and their pedagogical skills limited. This is especially true for teachers of science and mathematics in the elementary grades and junior high school:

Receive very little continuing education in science and mathematics. As NSF support of teacher institutes and workshops has dried up during recent years, the states and universities have not filled the gap.

Are being required to teach science or mathematics even though they lack proper qualifications. As vacancies occur, administrators sometimes find it expedient to misassign teachers from other fields who otherwise would be let go, especially since it is difficult to find qualified science and mathematics teachers. In most states, such assignments are permitted by law. The shortage of high school teachers of science and mathematics is due to radically reduced production (especially from the leading universities) and to industrial recruiting that is effective because of the low salary and poor working conditions of teachers today. Are confronted by social, demographic and political developments that are changing the circumstances of teaching. These include the increasing diversity of students they face (ethnic, social, economic, attitudinal, preparation), mandated accountability, and unionization.

THE GENERAL PUBLIC

Is losing confidence in the value of science. This is expressed by some as apathy, by others as hostility. The upsurge of mysticism and religious fundamentalism is a symptom of this.

Is withdrawing its support of public education. This may be due to such demographic factors as smaller family size and increasing average age, to percieved economic constraints, to loss of confidence in the schools, to changes in political philosophy, or to some combination of these. The decline of federal and local support of education in general especially hurts science, since it does not enjoy a high priority to begin with.

IN GENERAL

There is an absence of institutional or individual leadership in science education at either the school or university level.

We lack a theoretical base to guide research and practice in science education;

There is confusion about goals and objectives. It is difficult to have a sense or direction and purpose if there is no agreement on what science and mathematics knowledge and skills, at what level of understanding, should be expected of all well-educated Americans.

Fractionalism in American education not only makes any nationwide reform extremely difficult, it also makes it hard to detect and stem a gradual deterioration in the system as a whole. As the education system weakens so does science and mathematics teaching, perhaps disproportionately faster because of its nature.

KEY REFERENCES ON THE STATE OF SCIENCE EDUCATION

From the mountain of literature on the subject at hand, the sources listed here are, I believe, the most important. The first reference contains an excellent bibliography.

1. National Science Foundation and U.S. Department of Education. "Science and Engineering Education for the 1980's and Beyond" Washington, D.C.: GPO, 1980.

This is the report prepared at the request of President Carter. The result of lots of pushing and pulling, it nevertheless stands as the best current overview of both the career and general education aspects of the science education crisis. Of special interest are: Chapter V, "Science and Mathematics Education at the Secondary School Level," 45–52; Appendix B, "International Comparisons of Science and Engineering Education," 58–61; Appendix D, "List of Contributions," 65–71; and Appendix F, "Selected Bibliography of Published Sources," 73–79.

2. National Science Foundation. "The Status of Pre-College Science, Mathematics and Social Studies in U.S. Schools," Washington, D.C.: GPO. 1978.

This eight volume set was based on three commissioned studies: a national survey of educational practitioners, a series of in-depth case studies of educational programs and institutions, and the most extensive literature review yet undertaken. Two of the volumes are especially useful for policy makers. They are:

"The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies."

"What are the Needs in Pre-College Science, Mathematics, and Social Science Education?: Views from the field."

This volume (published in 1980) consists of interpretive reports prepared by nine different organizations after each had formed a study group to examine the substantive volumes. The organizations were: American Association for the Advancement of Science, American Association of School Administrators, Association for Supervision and Curriculum Development, National Academy of Science, National Congress of Parents and Teachers, National Council for the Social Studies, National Council of Teachers of Mathematics, National School Boards Association, and National Science Teachers Association.

3. National Assessment of Educational Progress. "Three National Assessments of Science: Changes in Achievement, 1969–1977." Denver: Education Commission of the States, 1978.

Not reassuring.

Mr. **Walgren**. Thank you, Dr. Rutherford.

We will go to the other members of the panel. Mr. Finnell.

[The biographical sketch of Mr. Finnell follows:]

Robert A. Finnell

Robert Arthur Finnell, Executive Director, MESA (Mathematics, Engineering, Science Achievement), Lawrence Hall of Science, University of California, Berkeley, has held his current position since July 1977. Prior to that he served as Deputy Director, Committee on Minorities in Engineering, National Research Council, National Academy of Science, Washington, D.C. Mr. Finnell is a member of the Committee on the Public Understanding of Science, American Association for the Advancement of Science; the Committee on Equal Opportunity in Science and Technology, National Science Foundation; the Management Advisory Review Committee, National Action Council on Minorities in Engineering; and the Equal Opportunity Advisory Committee, California Postsecondary Education Commission. In 1981 he received the Reginald H. Jones Award for Distinguished Service for his contributions to the minority engineering effort. Mr. Finnell has taught at the junior high school level in Texas and been on the faculties at the University of Pennsylvania and the University of Texas.

Mr. FINNELL. Thank you, Mr. Chairman.

I am Bob Finnell, executive director of MESA (mathematics, engineering, science achievement) which is based at the Lawrence Hall of Science, University of California, Berkeley.

I would like to focus my testimony on what we can do now to increase the number of secondary school students who are graduating from high school with the college preparatory mathematics, science and English that is necessary if they are to pursue a math-based field of study at a university.

For the past 5 years I have been directing MESA, a private sector, university high school program that is working with about 2,600 students in 100 California high schools. We have been graduating about 600 or more students every year with the academic background to pursue math-based fields. That experience has convinced me that when the expected results are clearly defined, when the focus is on improving academic performance of students, and when local companies, universities, and organizations are cooperative, then we can make progress in even the most difficult science education environments such as working with blacks and Hispanics in metropolitan suburban and rural areas.

MESA, like a number of other programs has developed a program model while working with minority students, but it is applicable to all students and is capable of replication. We have around the country about a dozen different models, and I will leave behind for your committee and staff descriptions of these models.

Mr. WALGREN. We would appreciate that, Mr. Finnell.

Mr. FINNELL. Thank you. But before I make some recommendations on what I think we can do now, I would like to comment briefly on what those models have in common because I think that if we do not look at what we have done over the past few years and what we have built on recently, we are going to continue to invest in some magic bullets, golden mousetraps, or ocean boiling kettles that waste resources that we cannot afford to lose.

The model programs I am talking about measure results. They work over a number of years with students. They work in cooperation with local organizations and individuals who have a stake in improving math and science education in communities. They work with the students in academic settings, whether it is during the school year, whether it is on Saturday, or whether it is in the summer. They measure their results.

The experience of those programs, I think, is extremely valuable. They have used, for example, a number of the projects that were funded by the National Science Foundation, by private foundations, and by companies. But I don't think that we can get to where we want to be by continuing in the directions that we have been going.

Furthermore, what we identified initially in the early seventies as a program needed because of the dirth of minorities participating in science and engineering has become a much wider problem.

I think it is important then that we have a national policy to develop our science and mathematics capacity so that we can achieve our nation's economic and defense objectives.

Because most of the dollars that were invested in minority educational programs were not in math based programs, minorities are generally not available at this time to participate in our economic and defense endeavors.

We are a high-technology nation. Our universities turn out many students with math-based discipline degrees, yet 99 percent of the dollars allocated for minorities are in nonmath-based areas. I am still baffled as to why we have had this double track!

We have an opportunity that reminds me of the construction man who, waking up one morning, sees fire in the east, flood in the west, tornadoes from the north, and hurricanes from the south. He picks up the phone and orders his employees to hire more employees, lease more equipment, and buy all the materials because there are going to be a lot of opportunities to rebuild when the four catastrophies hit! I think we are in that same situation in our secondary schools. But we need a plan with objectives if we are to get return on our investments.

Let me make five recommendations: First, I would like to recommend that we establish a national policy for improving the ability of our citizens to succeed in math-based disciplines and pursue this mission by setting the following objective for secondary schools: doubling within 3 years the number of students completing the first year of math and the first year of science, and quadrupling within 6 years the number of students completing the third or fourth year of math and science. We should have a similar objective with regard to computer literacy.

The adoption of these objectives should follow a process that involves all of the key institutions that are involved in this: major companies, foundations, State government, school districts, and so on.

Second, I want to recommend that we build on the successful program models that are now in place so that a larger number of students in junior and senior high schools are involved in multiyear programs where they receive services that improve their academic performance; not some one-shot career day, not some one-shot summer program, but something that will enhance their ability to succeed at the university level programs.

Prior to the expansion of MESA in California, more money was spent on annual banquets, on ads, and on conferences than was actually spent on working with the students in the junior high and high school setting. It has been remarkable for the MESA team to measure the resources that are now brought to bear on the 2,600 students in the program. We invest about $400 a piece in each student and a lot of time from the volunteers that work with us.

Third, I would like to recommend that the future science education programs involve the cooperations from those key local institutions (industry, universities, public schools, and other). We have had too many programs that tried to go it alone. Since the first of this year, I have seen half a dozen plans—both private and public—that are going to solve this problem by themselves! Several are golden mousetraps!

The involvement of key individuals at local institutions can be in the form of volunteer support or it can be financial. In the case of the Federal Government, I think it should only be a share of the action; and if there are Federal allotments, it should involve local matches and other kinds of incentives so that the local foundations and companies will buy into the effort.

That is the model that these dozen programs I was talking to you about have used over the past 5 years and it has worked.

Fourth, I would like to recommend that an increased share of the Nation's financial resources be invested in multiyear secondary school and university programs that increase the number of graduates completing math-based fields of study.

Approximately $750 million annually should be spent.

Before I explain what this would buy, let me emphasize that this is the total investment that would be made by a variety of institutions, local school districts, companies, foundations, universities, united funds, you name it.

I estimate right now that many times this is spent annually on many less focused programs, so it is not a matter of new dollars, it is reallocating existing dollars.

I think this amount will service approximately 2 million students at the 8 through the 12 grade level, that it will produce a minimum increase of 150,000 students prepared for math-based fields of study. It could provide supportive services particularly at the first 2 years of the university and my best and worst case estimates are that it would produce an additional 23,000 to 60,000 B.S. degree graduates.

An investment of this scope would provide approximately $150 million for the minority populations that are underrepresented in the math and science fields. It would serve approximately 385,000 minority students and would graduate 30,000 at the high school level. I estimate between 4,000 and 12,000 then would complete their B.S. degrees.

Finally, I would recommend that the incentives—that a number of incentives be developed for the purpose of stimulating increased private sector involvement in secondary school science programs. We have these in other areas that are vital to the Nation. A pattern of incentives here, I think, is equally vital. When we persuaded a number of companies to invest in precollege activities in the midseventies, it took corporate board action to do this because their focus had been on college or university activities.

These five recommendations have evolved out of my experience over the past 8 years of working mainly with the programs that were aimed at students who were underrepresented in math-based fields of study. Out of it I am convinced that we have the models, that we can expand them now, that they are relevant to the students we have been talking about today, and that we don't have to wait for studies; but it is a vital task to provide leadership so that the State agencies, local school districts, individual companies begin to allocate the resources within their control to this task.

Thank you very much.

[The prepared statement of Mr. Finnell follows:]

PREPARED STATEMENT OF ROBERT ARTHUR FINNELL, EXECUTIVE DIRECTOR, MATHEMATICS, ENGINEERING, SCIENCE ACHIEVEMENT [MESA], LAWRENCE HALL OF SCIENCE, UNIVERSITY OF CALIFORNIA, BERKELEY

Mr. Chairman and Members of the Committee: Thank you very much for the opportunity to appear before you today to testify on science and engineering education issues and programs. America's achievements in science, the expansion of our industrial capacity, and our ability to maintain a secure nation are related to the participation of students in mathematics and science programs in our secondary schools and universities. Recently, however, shifts in demographic patterns, the emergence of new technologies, incentives in noneducational institutions, and international opportunities have eroded the capacity of science and mathematics facilities at the secondary and university levels.

Because others have documented the decline in enrollments in college-preparatory math and science courses, the decimation of science teachers at the high school level, and the faculty and equipment problems at the university level, I would like to concentrate my testimony on what we should do to increase the number of secondary school students who graduate from high school with the college preparatory mathematics, science, and English courses and who have an interest in pursuing a math-based field of study (computer sciences, engineering, chemistry, physics, biology, and other fields that require calculus). My experience the past five years with MESA (Mathematics, Engineering, Science Achievement), a private sector/university/high school program working with 2,600 students, has convinced me that when the expected results are clearly defined, when the focus is on improving academic performance, and when local companies and organizations are cooperative, then progress can be made in even the most difficult science education environments. MESA, like other programs I will describe later, has developed a model while working with groups currently underrepresented in science and engineering that is applicable to all students and capable of replication in other disciplines.

Before examining the salient characteristics of operating model programs that can serve as vehicles for reaching more secondary school students, I would like to comment on why I believe there is a federal role in science education and to recognize what has been accomplished by past federal, corporate, and foundation investments in science education. Finally, I would like to recommend some specific actions and suggest how the use of existing program models can improve participation in mathematics and science at the secondary level and make it unnecessary to allocate resources to new, untested projects that could turn out to be magic bullets, golden mousetraps, or ocean-boiling kettles.

THE CASE FOR A NATIONAL SCIENCE EDUCATION POLICY AND AN EMPHASIS ON SCIENCE EDUCATION FOR GROUPS UNDERREPRESENTED IN MATH-BASED FIELDS

Improving our economy and strengthening our defenses are the highest priorities in America. Both priorities are dependent on the availability of professionals and support personnel who can function productively in high technology environments. Limited mathematical and scientific knowledge inhibits individual productivity and the ability to contribute to research and innovation.

However, in recent years enrollments in secondary school mathematics and science classes have been the reverse of what our high technology economy requires. Secondary schools have a reduced capacity to educate students interested in mathematics and science. Some school districts have created "magnet" schools with a focus on science or related fields; others have left it up to private schools, community colleges, proprietary schools, or science centers to offer what the neighborhood high school included in its curriculum. The result: thousands of high schools and hundreds of thousands of American students are not exposed to educational environments where they could develop their mathematical or scientific skills or develop computer literacy. Our nation's ability to achieve its objectives are reduced by this situation.

Making it a national policy to develop our secondary school mathematics and science capacity would be consistent with our economic and defense objectives and help us to achieve them.

A parallel case can be made for addressing the educational challenges posed by the groups in our population who are not pursuing mathematics and science programs at a reasonable rate. Blacks, Hispanics, American Indians, and others represent more than 18 percent of our population. Their reduced productivity because of minimal participation in mathematics and science courses further inhibits the nation's ability to function in high technology arenas.

But there is another relevant point. We are a high technology nation. Our universities graduate a high percentage of students who receive B.S. degrees in math-based fields of study. Yet most of the educational resources allocated to Blacks, Hispanics, American Indians, and other groups are spent on "non-math" areas at both the secondary and university level. Altering this pattern could produce more graduates who are vital to our high technology economy.

Some voices, however, assert that this shift in resource allocation can occur locally. It can, but it will take time and it might not happen. If we leave it to cities (like Atlanta, San Antonio, Los Angeles, Oakland, Chicago, Philadelphia, to name a few) or states where most of our minority populations are concentrated to take appropriate action, then we might not be making a choice that is available to us that is a better alternative for producing results in science education.

The alternative is to recognize that a policy emphasizing increased participation in secondary school student participation in mathematics and science is consistent with our economic and defense objectives. It is also a way of insuring that all of our citizens are pursuing fields of study that are vital, rather than involving some in fields that do not have as high a priority for the nation.

THE RESULTS OF PAST SCIENCE EDUCATION INVESTMENTS

Investments made in science education for the past decade or more by the National Science Foundation, private foundations, corporations, and other agencies have given us a base on which to build. Many of the secondary school programs I am associated with have benefited from curriculum development projects, teacher training institutes, or summer academic programs funded by government agencies. Grants made by the Sloan Foundation and the Hewlett Foundation have converted concepts into tested, operational programs that have demonstrated that progress can be made when certain frameworks are adhered to. Corporate support by dozens of high technology companies has been critical in the creation of engineering and science high schools and university support programs for minority students.

I trust that as we plan for the future, we will not ignore the achievements produced by our past policies. At the same time, I trust that we will recognize that new conditions and pressures require modifications where necessary, expansion where necessary, and termination where necessary of programs or activities that were implemented in the past. Some science education projects, both public and private, had objectives that were not related to building capacity in high technology areas. Some resources were allocated as charitable ventures, not investment opportunities. Some responded to an immediate crisis rather than to a long-term, national need. Some ignored cooperation among different institutions. In light of our past experience, what can be recommended?

RECOMMENDATIONS FOR SCIENCE EDUCATION

First, I would like to recommend that we establish a national policy of improving the ability of our citizens to participate and succeed in math-based and related disciplines that are essential to the nation. We can then pursue this mission by setting the following objectives for secondary school programs:

Doubling within 3 years the number of students completing the first year of mathematics and the first year of biology prior to or during the 10th grade;

Quadrupling within 6 years the number of students completing the third or fourth year of college preparatory mathematics and science, or the equivalent, prior to graduation from high school; and,

Establishing similar objectives with regard to computer literacy.

Adoption of these objectives will lead to program investments that will increase the number of high school graduates with the option to pursue fields that are critical to our economy, our research agenda, and other vital interests. Adoption, however, should occur through a process that involves the key institutions and organizations with roles to play during implementation of programs and activities. Donors (corporate, foundation, and governmental), educational institutions (university, secondary school, science centers, and others), professional associations, civic organizations, and others would be essential to the process.

Second, I would recommend that we build on successful program models now in place so that a larger number of students in junior and senior high school are involved in multi-year programs where they receive services that improve their academic performance and enhance their ability to succeed in university level degree programs. Building on tested programs will enable us to stretch our limited resources because start-up costs will be lower. For example, the replication of MESA in Colorado meant materials developed in Calfornia did not have to be "re-invented" or training modules for staff did not have to be developed from scratch.

Another gain will be that action programs can be initiated immediately rather than waiting several years to determine if a particular approach is effective and replicable. Programs like PRIME in Philadelphia have demonstrated that intervention from the seventh grade on can alter the preparation pattern of Black and Hispanic students. Over 500 are now pursuing engineering study. In Texas minority freshman enrollments have increased 58 percent since TAME began its activities. MESA in California has produced approximately 600 graduates in each of the last 3 years. Other programs described later in this testimony have achieved similar results with students and in teacher training.

Third, I would recommend that future science education programs involve cooperation from the key local institutions and organizations that have a stake in increasing student enrollment and completion of mathematics and science programs. The involvement should be on two levels: (1) financial, and (2) in-kind or volunteer support from individuals. Allocations by federal or state agencies should also involve a match, or an appropriate level of funding, from foundations, corporations, or other organizations. At the same time, students should have contact with volunteers and role models from industry, universities, professional societies, and other organizations.

Involving local companies, universities, and others in science education projects means that ownership is local and that a stake in the effectiveness of the project is held by individuals who are not directly involved in secondary school education. They can be critical and constructive from the inside, rather than feeling someone else is responsible for the project's success. It also means responsibility is shared rather than letting one company, agency, or association have a responsibility that involves each of the key local institutions and organizations. The fourteen programs that I am associated with have the active involvement of industry, universities, school districts, government agencies, professional societies, minority organizations, and other key groups.

Fourth, I would recommend that an increased share of the nation's financial resources be invested in multi-year secondary school and university programs that increase the number of graduates completing math-based fields of study. Approximately $750 million should be spent annually. Before I explain what this investment would buy, let me emphasize that this is the total investment that should be made by a variety of institutions: local school districts, corporations, foundations, universities, United Funds, and other. I estimate that many times this amount is spent annually now on less focused programs. The investment I am recommending will buy academic services for 2 million students at the junior high and senior high school level (8th grade through 12th grade).

It would probably produce a minimum increase of 150,000 students annually with the preparation for math-based fields of study. It would also provide the supportive services at the university level that can increase the chances that students will complete degrees in math-based or related fields of study. My best and worst case estimates are that an additional 23,000 to 60,000 B.S. graduates would be produced.

The investment would also provide approximately $150 million for the segments of our population who are currently not participating in math-based fields of study at the rates expected. Approximately 385,000 minority students would be served and perhaps 30,000 additional students would graduate from high school with the preparation they need. I estimate 4,000 to 12,000 more minority students could then complete degrees in math-based fields.

Finally, I would recommend that incentives be developed for the purpose of stimulating increased private sector involvement in secondary education science programs. We already have a variety of incentives that produce action in areas of the economy that are vital to the nation. A similar pattern of incentives, especially under present economic conditions, could produce similar results in the area of science education. Many corporations have had to establish new policies when they invested in pre-college programs. Their participation, while increasing, is still far below what it could be. Incentives could alter this pattern.

These recommendations have evolved out of my experience from working with groups underrepresented in math-based fields of study. The program models we have used, however, were not special models with a restricted application. Indeed, they are relevant to science education for all students. Therefore I would like to comment on what we have learned from these programs.

LEARNING FROM PAST INVESTMENTS

Investments made in secondary school and university programs in mathematics and science during the past ten years have provided us with a wealth of experience that can guide us as to what to do, and what not to do, in the future. Building on this experience can insure that future investments produce results that are essential to the growth of our American institutions. Using as an example the secondary school and university programs aimed at increasing the number of high school and university graduates completing math-based fields of study, I would like to enumerate eight program characteristics that should be incorporated in future efforts.

First, the successful programs have a defined, measurable objective aimed at increasing the number of graduates that is consistent with the needs of the professions, the high technology industries, and the health of the nation. For example, secondary level programs have the objective of graduating more high school students with the 3 or 4 years of mathematics, science, and English required for math-based fields of study. They also aim at developing the computer literacy, study, test-taking, and coping skills required for success in postsecondary education. University programs aim at producing more B.S. graduates in engineering, computer sciences, and other fields required by high technology fields.

Second, these programs provide incentives and recognition to students who achieve in academic courses that give them the option to pursue a math-based field of study. They do not reward the non-performer.

Third, they use a cooperative network of professionals and volunteers from industry, universities, public schools, professional societies, and other groups. These individuals provide a variety of services that motivate students or improve their academic performance. The services include tutoring, study group workshops, field trips, summer employment, math and science competitions, computer training, and similar activities.

Fourth, they create a sense of community among students so that their interest in academic pursuits and math-based careers is reinforced by what they hear from each other, their parents, their teachers and volunteers.

Fifth, these programs work with students on multi-year basis—from junior high on, or in high school. On the university level, support programs concentrate on the first 2 years. The programs do not focus on one-shot, disjoined events that lack follow-up.

Sixth, these programs have a professional staff that relishes the challenge of building the trained manpower pool for technical fields. They are managers. They motivate others; they can build academic skills in students. They are not sloganmakers or kamikaze pilots who spend their time dive-bombing institutions that are "responsible" for "the problem."

Seventh, these programs have multi-institutional sources of funding. Support comes from a mix of companies and foundations, public schools, universities, and/or government agencies. And just as important, these funds are spent on students services that increase the supply of prepared graduates.

Eighth, these programs measure costs and results; they measure enrollments, course completions, graduations, and/or teachers trained. They measure the output of their program in relation to the resources invested.

In summary, a variety of programs working in different geographic areas of the United States have over the past 5 to 10 years developed effective models for preparing and motivating more students to pursue math-based fields of study. These efforts at the high school level have been complemented by university level programs that are producing increased number of B.S. graduates. To cite one discipline as an example, engineering, is to measure what can be produced by systematic, constructive intervention. Freshman enrollments for Black, Hispanic, and American Indian students total over 11,000 as compared to approximately 3,000 in 1973. B.S. degrees awarded to Blacks went from 378 in 1970 to 1,445 in 1981. B.S. degrees awarded to Hispanics and American Indians have more than doubled in the same period.

Both the secondary school and university programs have formed associations, but to illustrate the availability of existing networks for increasing the number of secondary school students with better mathematics, science, and English preparation when they graduate from high school, I would like to describe the National Association of Pre-College Directors (NAPD) and its member organizations. This description will document the existing partnership of industry, public schools, universities, community organizations, professional societies, and government agencies.

NATIONAL ASSOCIATION OF PRE-COLLEGE DIRECTORS (NAPD)

The National Association of Pre-College Directors (NAPD) is a network of secondary school programs which focus on career choice and preparation in mathematics, science and engineering. The NAPD network began to take shape in July 1978, when six pre-college program directors met in Berkeley, California. Since then, the group has met semi-annually to review program operations, analyze common opportunities and problems, and interact with other groups interested in secondary school programs aimed at increasing the preparation of underrepresented minority students for careers in mathematics, science and engineering.

Programs in the NAPD network have built effective regional staffs that deliver a mix of services which improve the pattern of enrollments in secondary school math and science courses and increase students' interest in pursuing mathematics, science, engineering, and related disciplines at the university level. Cooperative action strengthens each individual program. It was with this understanding that the pre-college directors organized NAPD in Philadelphia in August 1979. The original members were joined by additional program representatives so that by 1981 NAPD represented the largest association of programs aimed at secondary school minority students.

NAPD'S OBJECTIVES

NAPD's objectives are (1) to increase the exchange of information, in-service training, and coordination among NAPD members and similar groups, and (2) to increase the level of financial and volunteer support for pre-college programs among corporate, foundation, and local, state, and federal agencies.

THE CASE FOR NAPD

During the past five years a growing number of reports and studies have documented the need to improve the academic skills of students from minority groups historically underrepresented in math, science and engineering. The continued growth of these disciplines and professions has become vital to the U.S. economy. Yet, though the economy is increasingly based on technology, serious shortfalls of scientists and engineers are developing at a time when record numbers are needed. In response to this need, secondary school-level programs geared to prepare and interest underrepresented students have been implemented in several regions of the nation. These efforts have been supported by a mix of donors in industry, foundations, and governmental agencies. Although, the programs work in a variety of ways, they all share common goals. Hence the need for NAPD.

NAPD provides these programs with a communications network for sharing ideas, resources, and information. Moreover, NAPD offers foundations, companies, governmental agencies, and other institutions an opportunity to tie into this network to readily learn about the variety of approaches being used to meet the nation's need. Through NAPD, representatives of these institutions can discover what their own role can be in helping to continue or expand these effective programs. And by participating, they demonstrate that they are working partners in an effort which is increasing the number of secondary school graduates prepared to enter university disciplines and professions which provide much of the leadership and decisionmaking personnel for our key institutions.

REQUIREMENTS FOR NAPD MEMBERSHIP

To qualify for membership in NAPD, a pre-college program must, (1) increase the pool for academically qualified minority students interested in engineering and related fields; (2) provide junior or senior high school students with service that prepare them for university disciplines requiring math and science; and, (3) involve representatives of public school districts, universities, industry, parents community groups and other interested organizations on its board of directors.

NAPD PROGRAM CHARACTERISTICS

Collectively, NAPD members deliver educational services to underrepresented minority students and/or their teachers in 24 states and the District of Columbia—geographic areas where the majority of the nation's minority student population resides. NAPD programs share the following common elements: an objective of increasing the numbers of high school graduates prepared and motivated to pursue a mathematics-based discipline, particularly engineering, at the university level; close working relationships with secondary schools, universities, industry, professional societies, minority organizations, and/or government agencies; one-to-one contact with students and/or teachers; and tracking of students.

Although NAPD programs take different to interacting with students and teachers, the typical program includes early identification of high-aptitude students interested in math-related fields; motivation activities such as field trips, role model speakers, and career counseling; academic activities such as computer courses, study/test-taking workshops, and Saturday or summer enrichment programs; and recognition awards or events for achieving students.

NAPD COORDINATION ACTIVITIES

NAPD members meet twice annually. Key agenda items cover development initiatives, as well as discussion issues, policies, and program refinements or improvements. These meetings also provide an opportunity to examine emerging regional or metropolitan organzations which have developed with the assistance of NAPD members. NAPD meetings can be combined with other meetings at a common site when a wider audience is appropriate.

NAPD DEVELOPMENT ACTIVITIES

NAPD's development activities include the following:

Preparation of a case for support of pre-college programs

This includes the goals and rationale for pre-college programs, statistical data on educational needs and opportunities for intervention, a description of precollege programs, budgets, and program results to date.

Contact with selected corporate, foundation, and educational organizations with an interest in pre-college programs

An exchange of information with educational policymakers at the federal and state level

Emphasis is placed on using existing resources as well as on defining new resources for pre-college programs.

Workshops with industry, foundations, and others

A minimum of two workshops per year are scheduled, some national, others regional. Participants review the case for support, discuss issues and questions associated with pre-college pool-building, and study program results. The workshops also serve as a vehicle for encouraging new pre-college programs in regions contiguous to the current members of NAPD.

Common proposal packages

These proposals can be directed to private or public institutions and can involve either program support or common curriculum, training, or evaluation activities.

NAPD STANDING COMMITTEES

Research data collection

Responsible for gathering information relevant to NAPD objectives.

Resource development

Develops strategies for raising funds.

Membership

Responsible for evaluating and nominating potential members. The chairman of this committee sometimes extends invitations to non-members to attend NAPD meetings as observers.

NAPD AND OTHER GROUPS

NAPD works in close cooperation with several other organizations involved in the effort to expand the participation of underrepresented minority students in engineering and related fields, including: Association of Minority Engineering Program Administrators (AMEPA); Junior Engineering Technical Society (JETS); National Action Council for Minorities in Engineering, Inc. (NACNE); National Coordinating Center for Curriculum Development (NC^{3}D).

FOURTEEN NAPD PROGRAMS

The following paragraphs describe fourteen (14) programs associated with NAPD.

Accent on mathematics, engineering and science of Arizona [AMES]

AMES is a new effort patterned generally on MESA in California and TAME in Texas. AMES is concentrating its initial activities in major secondary school districts, community colleges and state universities in the Phoenix and Tucson areas.

Most of the program's services are delivered by physical scientists, engineers, computer specialists, and industrial relations professionals. In addition to a variety of direct services, AMES is involved in fund-raising and program support for Arizona State University and University of Arizona summer programs for minorities and females related to engineering and the sciences. More information about AMES is available for Joe Levang, President, AMES of Arizona, Motorola, Inc., Semiconductor Group, 5005 E. McDowell Road, Phoenix, Arizona, 85008, (602) 244-4853.

Committee on institutinal cooperation plus midwest program for minorities in engineering (CIC+MPME)

CIC+MPME is a large and extremely complex program. Generally known as "The Midwest Program," it is spread over seven midwestern states—Illinois, Iowa, Indiana, Michigan, Minnesota, Ohio and Wisconsin. Created in 1975 by the engineering deans of the original participating universities, the Midwest Program today involves eighteen universities through ten distinct programs for students. Some serve very large numbers of students, while others are comparatively small. Most are based in the schools, though some are community-based. In addition management systems, program components and costs, and grade levels are all geared to local conditions and needs.

One of the programs within CIC+MPME is the Detroit Area Pre-College Engineering Program (DAPCEP), a consortium that is itself larger than most other NAPD programs. Through DAPCEP, five universities collectively work with the school system to provide tutorial and other services to more than a thousand students. DAPCEP was highly influential in Detroit's decision to create a high school dedicated to a math and science curriculum—Renaissance High School. In addition, one of the corporations working with DAPCEP operates a student program in computers and mathematics on its company site.

The program at Indiana University and Purdue University (Indianapolis) is another effective program enjoying strong support from industry. Geared to move 70 students into the engineering pipeline each year, it consists of summer workshops at three levels, a yearly academic program, and industrial experience during the summer after high school graduation. More information about CIC+MPME is available from Nathaniel Thomas, Director, Office of Special & Minority Projects, CIC+MPME, Illinois Institute of Technology, E-1 Bldg., Chicago, Illinois, 60616, (312) 567-5111.

Colorado Minority Engineering Association [CMEA]

CMEA began working with secondary school students in Colorado Springs in 1980, after nearly 2 years of careful planning and organizing. CMEA develops and implements educational programming designed to provide "opportunity tracks" in engineering and science for all minorities, women, and disadvantaged youth in Colorado. The pre-college effort looks to California's MESA program as a model and bears the same name. CMEA's MESA program offers an array of student services in junior and senior high schools in the Denver and Colorado Springs areas. In addition, the program sponsors parent training workshops and actively involves local clergy and professional groups. CMEA operates a college-level Minority Engineering Program as well. More information about CMEA is available from Miguel A. Garcia, Executive Director, CMEA, College of Engineering & Applied Sciences, University of Colorado, 1100 14th Street, Room 414, Denver, Colorado 80202, (303) 825-6051.

Comprehensive math and science program [CMSP]

New York City's CMSP is financially sponsored jointly by the City's Board of Education and several large industrial firms. CMSP aims to increase the pool of students who achieve at a high level in their study of pre-algebra and algebra and works at developing strategies to heighten student awareness of the importance of math and science achievement for future success in college and careers in the fields of engineering, science and technology.

Six New York City area engineering colleges work cooperatively within the Consortium of Institutional Networks (COIN) to provide resources to participant high schools. CMSP offers college and career seminars, field trips to industrial sites, curriculum materials, and a college experience and orientation program. More information about CMSP is available from Gil Lopez, Director, CMSP, School of Engineering & Applied Science, Columbia University, New York, New York, 10027, (212) 228-0950.

Forum to advance minorities in engineering [FAME]

FAME was created with the financial support and coordinating expertise of local industries in Wilmington, Delaware in 1976. FAME began its work with programs conducted during the regular school year, later expanding its services to include a variety of summer enrichment programs. One of these, attended by students completing the tenth grade, is held at Widener College and stresses physical science and computer science. Students entering their senior year may attend a 6-week summer residential program at the University of Delaware which introduces them to college life and prepares them through courses in pre-calculus, computer science and physics.

In addition to a variety of school year activities, students participate in Saturday Science Clubs. A Test Awareness Program has been added to the club's activities, helping prepare FAME's students to take the PSAT and SAT. More information about FAME is available from John Mathis, Executive Director, FAME, 10th & Orange Streets, N-12507-3, Wilmington, Delaware, 19898, (302) 744-8547.

Louisiana engineering advancement program for minorities [LEAP]

LEAP is a joint venture by businesses, universities and local community organizations. After more than 15 months of planning and organizing LEAP began its pilot effort in 1980 by working with junior and senior high school students in six New Orleans schools. LEAP will eventually service other major population centers in Louisiana where there are large concentrations of minority students.

Offering a wide range of program components, LEAP involves professional engineers as student project advisors, lecturers, field trip organizers, summer job organizers, and general consultants to teacher and LEAP staff. More information about LEAP is available from George W. Baker, Executive Director, LEAP, Xavier University, New Orleans, Louisiana, 70125, (504) 482-4837.

Massachusetts pre-engineering program for minority students [MASSPEP]

MASSPEP began in the Boston and Cambridge, Massachusetts public school systems in 1979. MASSPEP works with seventh through twelfth grade students. Each MASSPEP school forms a planning team consisting of mathematics, science, and English teachers and a guidance counselor. One of the team members acts as a coordinator and is responsible for developing and implementing the program in his or her school. Through these team efforts, activities, projects, and programs have been developed to motivate and interest minority students in engineering. Curriculum materials supplement math, science, and English classes. A summer program for teachers focuses on career counseling training.

Each MASSPEP school also has access to a variety of business and government organizations which provide field trips, speakers, demonstrations and role models. A Parents' Group provides active, year-round support. Supplementing the school year, accelerated learning programs are held at university campuses during summer and on Saturdays. More information about MASSPEP is available from James R. Patterson, Executive Director, MASSPEP, Wentworth Institute of Technology, 550 Huntington Avenue, Boston, Massachusetts, 02115, (617) 427-7227.

Mathematics, engineering, science achievement [MESA]

California's MESA is designed to graduate underrepresented minority students from high school with the 3 to 4 years of mathematics, science, and English preparation necessary to pursue a math-based field of study. Since it began in 1970, MESA has delivered a variety of educational services to students aimed at stimulating their enrollments and success in college preparatory high school courses. The program currently operates in more than 100 high schools where 2,600 students participate in MESA Activities. Approximately 650 MESA students now graduate per year with the educational background they need to succeed in mathematics, engineering, and the physical science at a university. Follow-up studies find that more than two-thirds of MESA's graduates select math-based majors in college.

MESA offers summer academic programs, tutoring, field trips, speakers and other services to students who are recognized as making an extra effort to prepare themselves for math-based fields at the university level. Through fifteen centers, usually based at a university academic unit, students also interact with volunteers from industry, professional societies, university faculties, government agencies, and others. High school teachers and counselors attend training workshops, which bring them together with center coordinators and educational specialists. A statewide Industry Advisory Board actively involves representatives from industry, and local advisory boards provide forums for hundreds more. More information about MESA is available from Robert Finnell, Executive Director, MESA, Lawrence Hall of Science, University of California, Berkeley, California, 94720, (415) 642-5064.

Metropolitan Consortium for Minorities in Engineering [METCON]

The engineering schools of four universities participate in the District of Columbia Metropolitan Consortium for Minorities in Engineering (METCON). Local industries and federal and community agencies also collaborate in METCON's pilot effort for D.C. schools.

METCON began in late 1979, receiving grants from a host of private corporations. The program has swiftly made use of existing resources by supporting student projects in local science fairs, taking an active role in the Career Fair for Washington, and supporting a special summer program in cooperation with NASA's Goddard Space Flight Center. METCON fills out its young program with a full range of student, teacher and parent services. More information about METCON is available from Elbert L. Cox, Director, METCON, School of Engineering, Howard University, Washington, D.C., 20059, (202) 636-6598.

Philadelphia regional introduction for minorities to engineering [PRIME]

PRIME, founded in 1973, identifies minority students in grades 7 through 12 who have high aptitude in science and mathematics. Serving Secondary schools in the Greater Philadelphia Region, the PRIME program offers a comprehensive and structured service of activities both during the academic year and the summer months. Academic year students so identified are placed in separate classes, with specially trained teachers, and are monitored by PRIME staff throughout the students' entire sequence in the program. Each industry within PRIME "adopts" a junior and/or senior high school and through this link-up a variety of simulated "hands-on" activities, field trips, tutorials, and career guidance activities are provided.

The Summer Programs include a 4 year, month long, college enrichment program beginning at the post-eighth grade. Students who complete the subsequent three summers are provided with an 8 week industrial internship in one of a dozen area companies. The summer program also includes a post-seventh grade Reading Clinic for 125 students who, over a span of 8 weeks, read a book a week, write reports, and are monitored closely by several reading specialists. Finally, PRIME offers a week long Summer Institute for teachers to up-date skills and show how mathematics and science can be applied to real world technology.

More than 42 businesses and government agencies participate as well as area colleges/universities, parent and civic organizations. Currently, more than 2,500 students in grades 7 through 12 are provided services. Each year PRIME graduates approximately 150 students who have completed three or more years in the program. Of its first graduating class of 64 students in 1977, 21 graduated in June of 1981 with an engineering and/or technology degree. More information about PRIME is available from W. Barry McLaughlin, Executive Director, PRIME, 260 S. Broad St., 20th Floor, Philadelphia, Pennsylvania, 19102, (215) 735-0872.

Program for Rochester to interest students in science and math [PRIS²M]

PRIS²M is the brainchild of Rochester industry, which is based largely on technology and requires increasing numbers of technically trained and professionally educated people to carry on its work. With the enthusiastic cooperation of the City School District, PRIS²M is working with administrators, faculty, and students in many Rochester schools with large minority populations. These range from elementary to senior high schools.

PRIS²M is funded entirely by Rochester industries. They support the purchase of innovative and stimulating curriculum materials used to supplement science and math courses, the training of teachers to use them, and all administrative expenses. In addition, role models from industry interact with PRIS²M students at every grade level. Industries further assist by giving PRIS²M students work experiences related to their studies. The City School District selects the schools in which the program operates and the students who participate. PRIS²M offers a growing list of services. More information about PRIS²M is available from Constance Mitchell, Community Relations Coordinator, PRIS²M Office, Industrial Management Council, 12 Mortimer Street, Rochester, New York, 14604, (716) 325-5139.

Southeastern consortium for minorities in engineering [SECME]

Representatives of twenty-one engineering colleges in eight states work together as a team known as SECME. Begun in 1976, SECME is the largest of NAPD's programs, serving thousands of students in Alabama, Georgia, Florida, Mississippi, South Carolina, North Carolina, and Tennessee.

Engineering College faculty help nearby school systems develop local SECME projects designed to increase the numbers of underrepresented minorities in the engineering profession. Secondary school administrators who have the authority to implement new programs work with teachers from appropriate subject disciplines to design a project which meets local needs as well as SECME goals. Three major components must be designed for the project:

A plan for enriching and supporting mathematics, science and language arts curriculum.

An engineering guidance program.

A method for utilizing community resources such as local industry, professional and parent groups.

Each school system is required to have a minimal financial investment in the project. Cost-sharing is increased each year until the project is totally supported by funds from the school system and local industry.

Each newly funded school system is required to send at least two representatives to the SECME Summer Institute, where teachers and counselors are given an overview of engineering as a profession and an awareness of the opportunities for minorities in engineering. They are introduced to curriculum enrichment materials and make plans with engineering faculty coordinators on the operation of their local projects for the coming school year. More information about SECME is available from Carolyn C. Chesnutt, Executive Director, SECME, Georgia Institute of Technology, Atlanta, Georgia, 30332, (404) 894-3314.

Texas alliance for minorities in engineering [TAME]

Texas educators and industrialists created TAME in 1975. At that time the minority school-age population of Texas was 40 percent and steadily increasing, yet only two to three percent of the engineering students in Texas colleges were black, Hispanic, or Native American.

Ten regions of the state (with 90 percent of its minority population) were identified for intensive work. In each of these regions, TAME brought together leaders from local industry, the public schools, universities and the community to create an alliance tailored to their local resources and problems. Methods and services vary from region to region, but emphasis in each alliance is upon the importance of the math and science sequence and early entramce into this sequence by minority students at the junior-senior high level—a must for students who hope to succeed in the demanding engineering curriculum. Today the number of minority students enrolled in Texas' twelve engineering colleges is dramatically increasing. More information about TAME is available from John S. Robottom, Executive Director, TAME, Box 19775, UTA Station, Arlington, Texas, 76019, (817) 273-2571.

To increase minorities in math and engineering [TIM^{2}E]

The cities of Providence and Newport, Rhode Island are served by TIM^{2}E. TIM^{2}E welcomed its first students in 1980 after nearly 2 years of preparation. Funded by corporations and foundations, the program's pilot effort works on a model similar to Philadephia's PRIME. TIM^{2}E works with seventh through twelfth grade students, emphasizing early identification of promising students.

An advisory committee in each participant school creates the local TIM^{2}E program. This committee includes employer representatives, a university faculty member, a university student, and teachers from the participant school.

In addition to a wide range of services, TIM^{2}E offers students Science Club (JETS) Advisors, a Technical Big Brother program, and a project in which students gain valuable experience by "shadowing" a professional engineer on the job. More information about TIM^{2}E is available from Raymond Stockard, Executive Director, TIM^{2}E, Gilbreth Hall, University of Rhode Island, Kingston, Rhode Island, 02881, (401) 792-2455.

Mr. WALGREN. Ms. Kreinberg?

Ms. KREINBERG. Thank you, Mr. Chairman.

I am director of the math and science program for women at the Lawrence Hall of Science, which is a public science center, teacher training institution, and a research and development center in science education at the University of California at Berkeley.

This work has involved me in the full range of educational activities from teaching elementary and secondary teachers, developing curriculum and instructional materials, and designing and evaluating programs for women reentering the scientific work force after a career break. It is from this perspective that I can comment on the science education needs of women and minorities, and what directions we need to be taking in this decade and beyond to develop and increase our pool of scientific and technical workers.

We elucidated the problems of science education pretty clearly in the last couple of hours. The one problem I would like to touch on is the need to enlarge the talent pool from which we draw future scientists and engineers.

The most promising sources of talent are women and minorities, who make up 60 percent of the population. In 1980, women were only 4 percent of the engineering work force, and racial minorities comprised only 6 percent of employed engineers. These figures indicate a substantial portion of our population will not be contributing to our scientific and technical advancement without special efforts to attract and retain them in the secondary and postsecondary fields of study to prepare them for these careers.

What can we do to increase the current and future pool from which we draw our scientific work force?

We can develop the pool from the earliest years, which involves a long-term commitment to science education at the elementary and secondary years.

We can retain the women and minorities who are currently undergraduates in the sciences by targeting them for special programs, and we can retrain and recruit people who are not currently using their scientific training.

Each of these approaches to reversing the attrition of women and minorities from science is being used within the science education directorate of NSF. This has been a relatively new focus, and an effective one. To illustrate just how effective, let me provide a few examples, beginning with the program for women resuming their scientific careers.

Promising Solutions: The women in science program was established in the science education directorate of NSF in 1976 to develop and test ways to increase the number of women preparing for and entering scientific careers. A series of 35 career facilitation projects have been funded since 1976 to assist women with degrees in the sciences to update their skills so that they can enter or reenter the scientific work force or graduate education in science.

These projects have served approximately 1,500 women for a cost of $4.8 million. The graduates of these programs, with combined yearly earnings of $3 million, have already repaid the cost of the program with tax dollars.

The projects vary from 6 to 24 months and focus on fields in which current employment demand is high.

Success stories abound on the individual level, where ultimately success is measured. One woman had a Ph.D. in crystallography but, after a 7-year absence from the university while she raised her children, she could not find suitable employment as a chemist in the Pittsburgh area. After participating in Chatham's College's NSF project, she is now working in analytical method development and research of toxic chemicals at Union Carbide's Bushy Run Research Center, earning over $25,000 yearly.

Another woman, a mother of nine and a housewife for 18 years, traveled 100 miles a day to attend American University's career facilitation project in chemistry in 1978. Today she is a full-time chemist with the city of Baltimore's Department of Water and Waste.

These career facilitation projects are thus providing a new strategy for solving the shortage of technically trained people and returning to the work force a previously ignored segment of the science population.

At the precollege level, important work in teacher education and curriculum improvement is going on through NSF-funded programs. For the last 5 years, with funds from the Department of Education to develop the project and funds from the National Science Foundation to disseminate it, my colleagues and I at the Lawrence Hall of Science have been conducting the EQUALS inservice program to assist classroom teachers, counselors, and administrators in acquiring methods and materials to attract and retain women students in mathematics courses.

In California, 1,500 educators have received from 10 to 30 hours of inservice instruction and another 2,000 educators in 25 other States have participated in the program. Evaluation data indicate that in schools in which we have been working for 2 or more years there is a slow but steady increase in the number of young women in advanced mathematics classes. Further, all students of teachers participating in our program demonstrate an improved attitude toward the study of mathematics and increased interest in math-related occupations.

Based upon the effectiveness of this program and because of a large number of requests from educators for more classroom materials, we applied for and received a grant in 1979 from the National Science Foundation to develop classroom materials that would provide middle through senior high-school students with mathematical experiences that emphasized the need for problem-solving skills while also increasing their awareness of the relationship of problem solving to scientific careers.

Among the materials developed was "Going to the Work force," an activity in which students predict and then verify how much math they will need to major in a variety of undergraduate fields—from electrical engineering to business administration. One teacher who used the activity wrote us:

"I played Going to the Work force with my three sophomore geometry classes. They enjoyed it, especially working as a group. Most groups worked smoothly, though one group of boys nearly came to blows. They were startled to learn how many fields require college math.

"I think the exercise did produce a positive result, immediately measurable. I did the activity 2 days before they signed up for next year's classes and close to 97 percent of my students signed up to continue on; that is, to take a third year of high school math. I was impressed. I did the same activity with my junior Algebra III class. The results were the same. I was equally impressed with the fact that 19 out of my 22 students signed up for trigonometry for next year."

This same teacher, who participated in EQUALS 3 years ago, has single-handedly increased the numbers of females in fourth-year math class, including calculus, in his school from 87 in 1979 to 118 in 1981.

"Going to the Work force" and 33 other activities we developed under this National Science Foundation grant were evaluated in 9 sites in California in third- through ninth-grade math classes. Students who used our materials made significant improvement over a comparison group on problem solving and spatial visualization abilities, on career interest and knowledge, and on identification of mechanical tools.

Each of the 34 activities has been used, on average, by 2,000 students to date. At a cost of approximately $5,000 per activity—the total grant award was $177,000—the cost per student of this effort was $2.50. When the materials become nationally available this summer, another 50,000 students will be reached.

Thus, our educational goals were achieved cost effectively, teachers and students are using the materials, and last week I shared these materials with 150 educators in Oregon who were attending a National Science Foundation conference designed to provide a forum for such exchanges between educational developers and practitioners.

I do not believe any of the types of activities I have described at the precollege and postsecondary level for women and minorities would have taken place without the impetus and direction of the National Science Foundation. In fiscal year 1981, the total funds obligated for specially targeted programs for women in the science education directorate amount to $3.8 million, which was one-half of 1 percent of the total fiscal year 1981 budget for the National Science Foundation. By any standards, these monies represent a very large return on a small investment.

The programs I have described are promising solutions; much, of course, remains to be done. The major components of change needed to increase significantly the participation of women and minorities in science over the next decade are: teacher preparation, curriculum improvement, increased course requirements, and industry-education linkages. All are essential to the success of this endeavor. Let me take each in its turn.

TEACHER PREPARATION

As mathematics teachers are lost to industry or retirement, they are being replaced by teachers who have had little or no formal training in mathematics. At the same time, the traditional support systems that have helped teachers gain competencies in new subject areas are being withdrawn. Federal and State cutbacks are eliminating most of the resources for teacher in-services that previously existed.

Rather than cutbacks, what is desperately needed at this time is a recommitment to teacher training in the form of summer institutes and academic-year services. New courses focusing on mathematical literacy need to be developed to help teachers acquire an overview and familiarity with mathematical topics.

CURRICULUM IMPROVEMENT

New courses are needed. The traditional junior-high shop course, for example, might be replaced by an introduction to technology, helping students learn how things work and to explore various technological sytems through "hands-on" activities such as building a circuit board or a solar panel. Girls, in particular, would benefit from such courses.

INCREASED COURSE REQUIREMENTS

It will be necessary to increase the mathematics and science requirements for high-school graduation if students are to achieve mathematical and technical literacy. Without the necessary teacher preparation and curriculum improvements, however, increased enrollments will not by themselves improve literacy.

INDUSTRY-EDUCATION LINKAGES

Sustained cooperation between industry and the schools is necessary to develop a pool of skilled workers. There are excellent opportunities for industry-school collaborations in the development of new curricula and teacher preparation, but it must be a two-way street. I have documented one such venture in my prepared statement.

Other types of industry-education collaborations can be developed. For example, "Research in Industry" projects could be arranged for high-school counselors to acquire employment information on brief leaves of absence. Mobile vans might travel to elementary and secondary schools, offering "hands-on" prevocational courses with tools and equipment not normally available in the schools. Both boys and girls could then have an opportunity to learn basic mechanical skills. Industry-education collaborations could lead to a more responsive curriculum and the better preparation of women and minorities entering the technical work force.

These are only a few suggestions about what needs to be done.

We are at a critical juncture. With Federal cutbacks, we look to the States to pick up the focus and planning that the National Science Foundation has pioneered in the development of programs to increase the numbers of women and minority scientists and engineers. The early warning signs indicate that, as we feared, the States do not and have not considered this an educational priority.

In my own State of California, where the Governor has recently announced a new initiative in math and science education and a proposed budget of $40 million to invest in all levels of education, little is being done about insuring the access of women and minorities to science.

Further, in my discussions with policymakers at the State level, I have become very concerned that the political demands of the varied constituencies will fragment this program and dilute it so greatly that little will be accomplished, if indeed the legislature passes the bill at all.

Alternate funding for this level of effort does not exist. No one but the Federal Government can take the national perspective and provide the necessary leadership. While a few programs may be completely financed by the private sector, and some may obtain multiple sources of funding, the majority of programs that address teacher training, student learning, curriculum improvement and dissemination of effective practices in the education of women and minorities will not be sustained or created without Federal support.

It will take a national commitment to make quality science education a national priority. NSF's science education directorate has provided the central coordination that enables all States to have equal access to successful programs, first by informing educators that such programs exist, second by providing resources for the States to obtain and adapt these models, and third by awarding seed money for promising approaches to increasing the participation of women and minorities in science.

This Federal coordination and development role must continue if we are to achieve our science education goals.

Thank you for the opportunity to present these remarks. I would be pleased to respond to questions.

[The prepared statement of Ms. Kreinberg follows:]

PREPARED STATEMENT OF NANCY KREINBERG, DIRECTOR, MATH AND SCIENCE EDUCATION FOR WOMEN, LAWRENCE HALL OF SCIENCE, UNIVERSITY OF CALIFORNIA, BERKELEY

Thank you Mr. Chairman, and other distinguished members of the Subcommittee, for the opportunity to discuss the impact of the National Science Foundation's science education programs on women and minorities. I am Director of the Math and Science Education Program for Women at the Lawrence Hall of Science, which is a public science center, teaching training institution, and research and development center in science education at the University of California, Berkeley. For the last ten years, my work has been to increase the access and participation of women and minorities in mathematics and science. This work has involved me in a full range of educational activities—from teaching elementary and secondary students and teachers, developing curriculum and instructional materials, and designing and evaluating programs to serve women reentering the scientific workforce after a career break. It is from this perspective that I can comment on the science education needs of women and minorities, and what directions we need to be taking in this decade, and beyond, to develop and increase our pool of scientific and technical workers.

THE PROBLEM

Nationally, we face shortages of computer professionals, engineers, and technicians, while students are graduating from high school with inadequate math, science, and computer skills to enter these fields of study and work. Only one-third of the school districts in the United States require more than one year of mathematics in grades nine through twelve, and only a third require more than one year of science. We are losing qualified math and science teachers to industry and retirement, and we are replacing them with educators within the schools who are unprepared to teach these subjects. Our current secondary school curriculum is in need of improvement, and introductory courses are particularly warranted in electronics, technology, and computer science for all students.

Our nation's future economic strength, productivity, and prosperity rely upon our ability to reverse these trends. Investments in science education must be made at the federal level to increase our pool of potential scientists, engineers, and technicians, and to provide our elementary and secondary teachers with the assistance and resources to accomplish this.

We cannot depend upon the states to meet these challenges. Everywhere, state funds for education are being severely cut back. Five years ago, only 55 percent of the states employed one or more specialists to coordinate their state's math and science education efforts. Today, state departments of education and local school districts are cutting back staff and losing subject matter specialists. Quality science education is not the first priority in a time of financial difficulties; certainly, developing a pool of women and minority scientists and engineers will rate even less attention from state educators. If we depend upon each state to solve the problems of math and science education in its schools, we will be in worse shape ten years from now than we are today. Federal leadership and resources are needed to carry out a focused plan of action that will fully develop our talent pool and provide the mathematically and scientifically literate populace we require in coming years.

A NEW POOL OF SCIENTISTS

Our traditional pool of scientists and engineers is not sufficient for our future well-being. We must bend every effort to increase that pool. The most promising sources of future talent are women and minorities, who make up 60 percent of the population. In 1980, women were only four percent of the engineering force and racial minorities composed only six percent of all employed engineers. Of the one million college-bound students taking the SAT's last year, two-thirds of the males, but only one-half of the females had taken four or more years of high school mathematics. These figures indicate that a substantial portion of our population will not be contributing to our scientific and technical advancement without special efforts to attract and retain them in the secondary and post-secondary fields of study that will prepare them for these careers. What can we do, then, to increase the current and future pool from which we draw our scientific workforce?

1. We can develop the pool from the earliest years, which involves a long-term commitment to science education at the elementary and secondary years;
2. We can retain the women and minorities who are currently undergraduates in the sciences by targeting them for special programs.

Each of these approaches to reversing the attrition of women and minorities from science is being used within the Science Education Directorate of NSF. This has been a relatively new focus, and an effective one. To illustrate just how effective, let me provide a few examples, beginning with the program for women resuming their scientific careers.

PROMISING SOLUTIONS

The Women in Science Program was established in the Science Education Directorate of NSF in 1976 to develop and test ways to increase the number of women preparing for and entering scientific careers. A series of 35 Career Facilitation Projects have been funded since 1976 to assist women with degrees in the sciences to update their skills so that they can enter or reenter the scientific workforce or graduate education in science. These projects have served approximately 1,500 women for a cost of $4.8 million. The graduates of these programs, with combined yearly earnings of $30,000,000 have already repayed the cost of the program with tax dollars.

The projects vary from six to 24 months and focus on fields in which current employment demand is high.

Success stories abound on the individual level, where ultimately success is measured: one woman had a Ph.D. in Crystallography but, after a seven-year absence from the university while she raised her children, she could not find suitable employment as a chemist in the Pittsburgh area. After participating in Chatham's NSF project, she is now working in analytical method development and research of toxic chemicals at Union Carbide's Bushy Run Research Center, earning over $25,000 yearly.

Another woman, mother of nine and housewife for 18 years, travelled 100 miles a day to attend American University's Career Facilitation Project in Chemistry in 1978. Today, she is a full-time chemist with the City of Baltimore's Department of Water and Waste.

These Career Facilitation Projects are thus providing a new strategy for solving the shortage of technically trained people and returning to the workforce a previously ignored segment of the science population.

At the precollege level, important work in teacher education and curriculum improvement is going on through NSF-funded programs. For the last five years, with funds from the Department of Education to develop the project and funds from the National Science Foundation to disseminate it, my colleagues and I at the Lawrence Hall of Science have been conducting the EQUALS inservice program to assist classroom teachers, counselors, and administrators in acquiring methods and materials to attract and retain women students in mathematics courses. In California, 1,500 educators have received from 10 to 30 hours of inservice instruction and another 2,000 educators in 25 other states have participated in the program. Evaluation data indicate that, in schools in which we have been working for two or more years, there is a slow but steady increase in the number of young women in advanced mathematics classes. Further, all students of teachers participating in our program demonstrate an improved attitude toward the study of mathematics and increased interest in math-related occupations.

Based upon the effectiveness of this program and because of a large number of requests from educators for more classroom materials, we applied for and received a grant in 1979 from the National Science Foundation to develop classroom materials that would provide middle through senior high-school students with mathematical experiences that emphasized the need for problem-solving skills while also increasing their awareness of the relationship of problem solving to scientific careers. Among the materials developed was "Going to the Workforce," an activity in which students predict and then verify how much math they will need to major in a variety of undergraduate fields—from electrical engineering to business administration. One teacher who used the activity wrote us:

"I played Going to the Workforce with my three sophomore geometry clases. They enjoyed it, especially working as a group. Most groups worked smoothly, though one group of boys nearly came to blows. They were startled to learn how many fields require college math. I think the exercise did produce a positive result, immediately measurable. I did the activity two days before they signed up for next year's classes and close to 97 percent of my students signed up to continue on; that is, to take a third year of high school math. I was impressed. I did the same activity with my junior Algebra III class. The results were the same. I was equally impressed with the fact that 19 out of my 22 students signed up for trigonometry for next year."

This one teacher, who participated in EQUALS three years ago, has single-handedly increased the numbers of females in fourth-year math (including calculus) classes in his school from 87 in 1979 to 118 in 1981.

"Going to the Workforce" and 33 other activities we developed under this National Science Foundation grant were evaluated in nine sites in California in third- through ninth-grade math classes. Students who used our materials made significant improvment, over a comparison group, on problem solving and spatial visualization abilities; on career interest and knowledge; and on identification of mechanical tools.

Each of the 34 activities has been used, on average, by 2,000 students to date. At a cost of approximately $5,000 per activity (the total grant award was $177,000), the cost per student of this effort was $2.50. When the materials become nationally available this summer, another 50,000 students will be reached.

Thus, our educational goals were achieved cost-effectively, teachers and students are using the materials, and last week I shared these materials with 150 educators in Oregon who were attending a National Science Foundation conference designed to provide a forum for such exchanges between educational developers and practitioners.

I do not believe any of the types of activities I have described at the precollege and postsecondary level for women and minorities would have taken place without the impetus and direction of the National Science Foundation. In fiscal year 1981, the total funds obligated for specially targeted programs for women and minorities in the Science Education Directorate amount to $3.8 million, which was one-half of one percent of the total fiscal year 1981 budget for the National Science Foundation. By any standards, these monies represent a very large return on a small investment.

The programs I've described are promising solutions; much, of course, remains to be done. The major components of change needed to increase significantly the participation of women and minorities in science over the next decade are: teacher preparation, curriculum improvement, increased course requirements, and industry-education linkages. All are essential to the success of this endeavor. Let me take each in its turn.

TEACHER PREPARATION

As mathematics teachers are lost to industry or retirement, they are being replaced by teachers who have had little or no formal training in mathematics. At the same time, the traditional support systems that have helped teachers gain competencies in new subject areas are being withdrawn. Federal and state cutbacks are eliminating most of the resources for teacher inservices that previously existed. Rather than cutbacks, what is desperately needed at this time is a commitment to teacher training—in the form of summer institutes and academic year services. New courses focusing on mathematical literacy need to be developed to help teachers acquire an overview and familiarity with mathematical topics.

CURRICULUM IMPROVEMENT

New courses are needed. The traditional junior high shop course, for example, might be replaced by an introduction to technology, helping students learn how things work and to explore various technological systems through "hands-on" activities such as building a circuit board or a solar panel. Girls, in particular, would benefit from such courses.

INCREASED COURSE REQUIREMENTS

It will be necessary to increase the mathematics and science requirements for high school graduation if students are to achieve mathematical and technical literacy. Without the necessary teacher preparation and curriculum improvements, however, increased enrollments will not by themselves improve literacy.

INDUSTRY-EDUCATION LINKAGES

Sustained cooperation between industry and the schools is necessary to develop a pool of skilled workers. There are excellent opportunities for industry-school collaborations in the development of new curricula and teacher preparation, but it must be a two-way street. I have documented one such venture in my prepared statement.

Other types of industry-education collaborations can be developed. For example, "Research in Industry" projects could be arranged for high school counselors to acquire employment information on brief leaves of absence. Mobile vans might travel to elementary and secondary schools, offering "hands-on" prevocational courses with tools and equipment not normally available in the schools. Both boys and girls could then have an opportunity to learn basic mechanical skills. Industry-education collaborations could lead to a more responsive curriculum and the better preparation of women and minorities entering the technical workforce.

These are only a few suggestions about what needs to be done.

We are at a critical juncture. With federal cutbacks, we look to the states to pick up the focus and planning that the National Science Foundation has pioneered in the development of programs to increase the numbers of women and minority scientists and engineers. The early warning signs indicate that, as we feared, the states do not and have not considered this an educational priority.

In my own state of California, where the Governor has recently announced a new initiative in math and science education and a proposed budget of $40 million to invest in all levels of education, little is being done about insuring the access of women and minorities to science. Further, in my discussions with policy makers at the state level, I have become very concerned that the political demands of the varied constituencies will fragment this program and dilute it so greatly that little will be accomplished—if indeed, the legislature passes the bill at all.

Alternate funding for this level of effort does not exist. No one but the federal government can take the national perspective and provide the necessary leadership. While few programs may be completely financed by the private sector, and some may obtain multiple sources of funding, the majority of programs that address teacher training, student learning, curriculum improvement, and dissemination of effective practices in the education of women and minorities will not be sustained or created without federal support.

It will take a national commitment to make quality science education a national priority. NSF's Science Education Directorate has provided a central coordination that enables all states to have equal access to successful programs. First, by informing educators that such programs exist; second, by providing resources for the states to obtain and adapt these models; and third, by awarding seed money for promising approaches to increasing the participation of women and minorities in science.

This federal coordination and development role must continue if we are to achieve our science education goals.

Thank you for the opportunity to present these remarks. I would be pleased to respond to questions.

Mr. **Lundine** [presiding]. Thank you very much.

Dr. Glaser?

Dr. **Glaser**. Who am I? I am a university professor at the University of Pittsburgh and I help direct a research institute that for some years has been concerned with getting major scientists from various fields to study the research on human learning and its relevance to educational technology.

I have had the good fortune to be president of and honored by the major professional associations in my field, and currently I am president of the National Academy of Education.

I hope to be informative to the awesome task you have before you, and to the deliberations that are involved.

The first thing I need to say is that I am rather appalled and frightened by the cuts recommended in science education improvement because I feel there is need to maintain the scientific literacy of our Nation with respect to the other competition in the world. I am very frightened of running out of trained brains and being in a situation where we were some years ago when we mostly relied on imported brains from the other side of the Atlantic.

I think our concerns with science education are not just concerns you heard with regard to the training of scientists. They go from the child through the adult and not just with graduate fellowships, as important as they are. We are not only concerned with trained scientists, we are also concerned with the technically literate populace and a work force in industry and in the military that had some appreciation of and basic ideas about what it means to be technically literate.

This holds true for the trained teachers at all levels of schooling. Rather than dealing in such generalities, however, I would like to talk about my own hometown and the activities there that go on, that are going on, and I think are replicated elsewhere in the Nation.

I particularly want to focus my remarks on the research and development aspect of the science education funds. I want to just talk with you about a few projects that are going on.

At the University of Pittsburgh and the Carnegie-Mellon University there is a group of individuals whose work is supported by the science education R. & D. funds. These include Nobel prize winners and others who are recognized as major theorists and experimentalists in their fields. In the development of their work, they have had the very intelligent support from the NSF science education development staff.

By accepting these science education funds, these scientists that work on some of the problems I am going to describe indicate that they are interested in scientific findings and its utility for the improvement of science education and science instruction. They all feel this is an extremely serious matter because the literacy requirements of our Nation are higher than they have ever been and the schools need assistance in reaching these new levels.

It is no longer enough to know how to do arithmetic; it is important to be able to apply them to important problems. It is no longer enough just to be able to read, because we attained the idea of most of the individuals in our country being literate, but we now have to be concerned with using that knowledge for technological distinction and for thinking about the problems that confront us.

I want to talk about two problems that these people in Pittsburgh and at Carnegie-Mellon University are working on with the support of these funds that will be cut off if these supports are not continued.

The first problem which is of great interest to these people is the nature of competence and the nature of expertise in scientific problem solving. With the help of people in the fields of psychology and artificial intelligence and computer modeling, they are concerned with examining the nature of problem solving and why people are expert in it.

Their work is to examine problem solving in experts and novices and beginners in relation to highly experienced people. They look at how problems are perceived by people with a great deal of experience, how people with a great deal of experience use their time efficiently in contrast to beginners in the field.

Their hope is that by understanding this process, they can shortcut experience by designed experience that can be placed in educational training programs and built into materials for education. They are also studying the naive misconceptions that most people, whether children or adults, have when they begin a course of study in science.

Their hope is to be able to utilize these conceptions to train in scientific literacy and utilize them to train people in scientific problem solving.

For example, a naive theory that most people have is that when something is in motion, the first question they ask is, what is pushing it? That is a perfectly commonsense question. According to the laws of physics, an object to be in motion doesn't require a force to push it because one of Newton's laws is that an object in motion tends to stay in motion without any outside force.

Some experience in understanding this principle gives them an appreciation of what happens when we launch a satellite. It also gives an appreciation of how to handle their car on slippery ice. Most people immediately try to accelerate the car by applying some force to change the direction. We have discussed this quite a bit, how to make them understand that you are supposed to allow the car to continue its motion and to try to change its direction.

This is a simple-minded idea, but an appreciation of these things would be very useful not only in scientific problem solving but in everyday living.

Currently my town is also utilizing this research which, in the form that it has been carried out for the past few years, has the usual encumberments of being a theory about the kind of theories that are needed to state things in scientific terms. These theories now are being used to begin to see how to train youngsters in school and how to move them from their naive scientific conceptions to more sophisticated understanding of science and to give an appreciation of how to approach scientific problems and what problem solving in science constitutes.

We currently have students from 13 high schools in Allegheny County who are learning to solve problems in science, and an extensive investigation has been made about how they and their parents think about science. This information is being used—together with the information about the efficiencies and knowledges and experience of experts—to guide their education.

Another problem that is being worked on with the funds that might be cut is the problem of mathematics and young children in elementary school, not only the problem of mathematics but the problem of being able to compute and being able to solve problems.

If you looked at the latest recent report of the National Assessment of Educational Progress, the results say that as a result of good teaching in the schools, people's ability to compute has improved, but people's ability to use their basic computation to solve problems has declined. There is no assumption that if you concentrate on the basics in mathematics that this is going to transfer to the ability to solve problems.

So research has been going on by these individuals to try to see how an understanding of the concepts of elementary numbers and developing a good capacity to make calculations can proceed together.

On the one hand, "You must learn to do your numbers with mathematics"; on the other hand, "You have to learn new math," and these have tended to be polar opposites and result in the growing up of people who can compute and don't know theory, or who know theory but can't use it when they are doing numbers.

People are trying to understand how children can remember mathematical concepts at the same time they build highly practiced skills. This is going on, so when they perform their computations in mathematics, when they do their mathematical work they do it with some sense of understanding, not just some ability to do mindless computations but be able to say, "Well, I really understand why I am carrying numbers in subtraction," "I really understand why the number I get from these things sounds silly."

So there is a great deal of work going on now on the relationship between teaching understanding and teaching also the great ability to be mathematically literate. This is leading into the development of a series of microcomputer lessons in which children are taught to do their numbers at the same time they are able to understand and make contact with the kinds of understanding in using their numbers so they can check back and forth between their calculations and what they had been taught about how numbers work and how numbers ought to be applied to practical problems.

What I am really talking about that is so important in science education is the production of adults that are sensitive to scientific literacy, which we require, who are part of a technologically adept work force that we require, and who are going to meet the new challenge of the things that are coming out and who can problem solve with the basic knowledge that they learn in schools.

Just basics of knowledge are not going to be satisfactory as we look toward the future. You have to learn to utilize your knowledge rather wisely. Schools will use the assistance that is coming out of the research that is going on.

I think that the people of tomorrow will need the ability not to be technological robots, but to be able to work with understanding and also be strong carriers and strong extenders of the things discovered in science. The things that are discovered in science cannot just proceed without a population of technically literate people that try to extend them, that make sense out of them, and have attitudes for their effective use.

This is the work that I think is going on, particularly in the utility of research for practical forms of education and practical forms of training people in technological literacy that I think would be dropped if this program weren't continued.

Thank you.

Mr. Brown [presiding]. Thank you very much, Dr. Glaser.

Mr. Gregg?

Mr. Gregg. Thank you, Mr. Chairman.

Mr. Brown. I will take off the 5-minute rule.

Mr. **Gregg**. I appreciate the presentations and I know there were some specific suggestions on education and how we should address education. I would like to get your comments, though, on whether you feel the bottom line of science education is an issue of dollars or an issue of programs?

Dr. **Rutherford**. I suppose it is both, right now it is a question of dollars and who will provide the dollars. The notion that problems can't be solved with dollars alone is true enough, but the converse is probably that not very many problems can be solved without them.

So I think the magnitude of the dollars is quite a separate question. I think of the ability of the Foundation to have programs that can attract other dollars. One example was given in Mrs. Heckler's briefing when she stated that in her district the Boston Science Museum was having trouble with fundraising in a given year. The sources had mostly run out. The museum received a Federal grant, but it was a matching grant. Almost instantly, inside of a few months, they were able to bring in three times as much money as the Federal Government put in.

So there is a serious question. Take the question of schools. The last time the laboratories of the schools of America had an injection of up-to-date scientific apparatus for teaching was during the period of the National Defense Education Act. That apparatus has not been replaced. It has not been repaired. In most schools it is sitting on the shelf.

Somebody needs to do something about that, but the money has to come from somewhere. So the question is: Will it come from the States? From gifts by industry? From the Federal Government? All of these?

Mr. **Gregg**. Anybody else?

Ms. **Kreinberg**. I would like to comment.

I believe with Dr. Rutherford we know a lot about good programs. NSF has been doing teacher training institutes for a number of years and has been funding good curriculum development. I think we know a lot about what kinds of programs need to happen.

I think the question really right now is where the dollars are going to come from. I don't believe they are coming from the States.

Mr. **Finnell**. I would still set the objective of doubling or tripling (pick a number) the number of students completing advanced math and science courses in the secondary school programs. When I asked friends who had various projects funded by the public or private sector, or a foundation, why after investments in science education there were declines in enrollments rather than answer they say to me, "Our job was to produce the film, to produce curriculum, to have the summer institute. We were not responsible for doubling enrollments or graduations."

In addition, when you look at high schools, they are not accountable for graduating students with trig and physics and chemistry. They are accountable for making sure attendance is high and that you complete so many units; it doesn't matter in what subject. Most of the mathematics units students take are really arithmetic. So as soon as you set a objective to achieve something the country needs, then you can determine whether the programs that you fund are consistent with what you want to achieve in math and science education.

When I went out to work with MESA, I had exclusively private funds from the Hewlett and the Sloan Foundations. We then went to the State legislature (after proposition 13) and were allocated $1 million over 3 years. Governor Brown is putting together for K through 12 a $20 million plan. Why? Because all of this discussion about precollege math and science education is having an effect on him.

Whether it will pass is another thing.

On the other hand, a few years ago when certain major companies announced, as a result of their benefits from proposition 13, they were going to put up $1 million for education, you should have seen the array of projects that eventually got funded: Discipline in the schools; vandalism; things like that.

I think had there been leadership they would have said, "Let's put our bucks into this math and science objective."

Dr. GLASER. There has been so much gained over the past 10 years in our understanding of problem-solving and of children's mathematics learning, that this would be an excellent time to bring teaching methods into line with current knowledge. Major changes in teacher training as well as in the instructional tools and organization of curricula are required if we are to benefit from what we have gained.

It seems to me that unless we are vigilant about keeping our citizens technologically competent—and other countries certainly are—we are going to lose out economically.

Mr. RUTHERFORD. I would if I might add one comment on an example of where it isn't a case of money.

You alluded to the problem of teacher salaries and the fact that science and mathematics teachers are being attracted into industry by higher salaries and are being replaced with people who are not trained in those fields, and that salaries is part of the problem.

That is not a problem that can be solved by State or Federal funds by trying to increase the salaries of science and mathematics teachers.

On the other hand, I cannot understand why we can't be a little more inventive in our policies. State policies could be changed to permit scientists who are in industry to help in the schools and sometimes to do some teaching, and teachers who are good in the schools to do some of their work in summers and the rest of the time in industry, so part of their pay scale is on standard industrial rates, part of it on the school rates at the standard school salary structure.

In a sense there wouldn't be any infusion of new money because industry wants the talents of those teachers. The school needs them, and it would mean that the physics teacher, instead of teaching two classes a day of physics and three of some other subject, might teach two of physics and use the rest of the time in productive ways in industry.

So I think if we look at it properly, there are some kinds of problems that would lend themselves to improvement merely by changing our policies.

Mr. **Gregg**. Thank you very much.

Mr. **Brown**. Mr. Rheem?

Mr. **Rheem**. Thank you, Mr. Chairman.

Mrs. Heckler had to leave and she wanted me to thank the panelists, especially Ms. Kreinberg, who alluded to some of the women in science programs that she is so interested in and has been following, and also for both Ms. Kreinberg and Dr. Finnell for coming out all the way from the Lawrence Hall of Science. Mrs. Heckler is very impressed with some of the science education programs that have been developed there.

She appreciates your endeavors, and certainly the entire panel.

She did have a question for Nancy Kreinberg involving publications that explain some of the work that you have done.

She wondered if you could leave some examples with the possibility of putting them in the record for the hearing?

Ms. **Kreinberg**. I would be happy to.

Mr. **Rheem**. Also, she was curious as to whether or not you thought curriculum development was an appropriate role for the Federal Government, especially the Foundation, to continue in or whether these things might more appropriately take place at the State and local level?

Ms. **Kreinberg**. I think it is essential that the Federal leadership in the women in science program continue because without it I think these programs will not exist or exist on an extremely diminished level. Now, Mr. Finnell said that he doesn't believe 1-day workshops do anything. I would have to disagree, having been a part of a number of ventures.

We have held 1-day science career conferences, sponsored by NSF. One conference was held for women with undergraduate degrees in the sciences who had been out of the work force for a while. We followed up on the 235 women who attended the conference 6 months later to determine whether they had done anything since the conference.

Of the respondents 75 percent had initiated a total of 353 new plans or actions relative to their careers, which they directly attributed to the conference, 68 had interviewed for new jobs; 39 took courses in math or science, 30 asked for promotions or raises and 116 investigated a new job. (Multiple responses were allowed.) That kind of stimulation to young and older women to consider entering the sciences is critical.

That initiative has come from the National Science Foundation and the leadership that has been there. I think without it we will not be seeing that kind of interest which is really essential.

Mr. **Rheem**. You mentioned teacher training was of very critical importance. Could you give us some examples or elaborate on some NSF programs you think have worked well in teacher training and that might be continued.

Ms. **Kreinberg**. I have worked with about 3,500 teachers in the last 7 years. A significant number of the ones who have been teaching for a while talk about the old NSF summer institutes. They say things like, "Who is going to pick those up? When are they coming back? Those were real in-depth experiences." The institutes gave those teachers training that they cannot receive elsewhere.

They miss them. They want them and need them. I believe if we are going to keep people in teaching we have to create an environment in which they can renew themselves professionally. The summer institutes as well as the academic year institutes are important ways to do that.

Mr. RUTHERFORD. Among the summer institutes, one of the last ones developed was called cooperative school science programs. The idea was that the teacher would not necessarily go off to some distant place for a summer institute, but to a nearby college or university for summer training, and that the relationship would be sustained during the academic year so that the university or college faculty would visit the school and work with the teacher there.

The teacher would take some courses, and you would build a sustained relationship between the local scientific community and local science teachers. It seems to me that of the variations on summer institutes and teacher training, that was the strongest, because it persisted over time.

Mr. RHEEM. One last question for Dr. Finnell.

Your program works very well at the State and local level utilizing local and State resources. What is your opinion of some of the NSF-sponsored education programs, and since the committee is considering whether or not they want to reprogram some money into the science and engineering education directorate, what kinds of programs do you think the Foundation should be involved in during a time of fiscal restraint and reduced funding?

Mr. FINNELL. The MESA program as well as some other programs I have worked with around the country like, PRIME in Philadelphia and TAME in Texas, and so on, have used some of the NSF funds for their summer programs and also for teacher training.

I think the main benefit was that there was a program underway and that that summer training or activity fit into it. Over a multiyear period, the students or the teachers who were in the program then could be followed up and you knew what happened to them. Whether you are a student or teacher, I don't think it matters where the funds come from; you want to know whether needed services will be delivered to you.

I think, on the other hand, where some funds were increased in, say, a summer activity that had no other possibility of followup because it was a one-shot kind of thing, we don't know what happened with those dollars. I would then agree with some of the previous testimony, that the meager funding of some very good programs has been a very serious problem, that if you do not have levels of dollars in there, you are not going to achieve the level of output you need.

So while I cannot say specifically what I would like to see in the NSF or any other organization, I think it is a $750 million problem. I think right now we are spending about $40 million on certain coherent programs around the country, and so we are achieving one-tenth or so of our objective.

As an example, in the minorities in engineering effort that I have worked in in the past 10 years, we have tripled and quadrupled the freshmen enrollments and the graduation rates for blacks and the Hispanic students. Now, when we started that effort we said it was going to cost us $30 or $40 million a year. But when we only spend $3 or $4 million a year to that effort, we achieved commensurate results, but not that tenfold increase.

So my concern is not in involving any institution or any one source of funding. I think the best use of NSF funds are possibly to leverage action out of other institutions because it is in the national interest that we prepare students for math-level fields. We are not going to be telling someone what to do when it's not in the best interest of the country, or the professions, or the students. But I think that the funds can be used to leverage action out of other "treasuries."

I think again there are some priorities for graduating prepared students from high school, that should have more emphasis because of the payoff that we can get immediately. But I wouldn't necessarily feel that a lot of studies or research would have as high a priority.

Mr. **Rheem**. Thank you, Doctor.

Thank you, Mr. Chairman.

Mr. **Brown**. Although I have a number of questions I would like to explore with the panel, I am going to refrain from that pleasure.

I therefore will excuse this panel with thanks for your excellent participation. We very much appreciate it.

I will call our last panel of the afternoon, Dr. Thomas Wenzlau, president, Ohio-Wesleyan University; Sarah E. Klein, president, National Science Teachers Association, and Dr. Saul Fenster, president, New Jersey Institute of Technology.

I want to express my great appreciation for your perseverance this afternoon. As I anticipated, the members of the committee have declined in numbers substantially, but may I assure you that the record of the hearing will make it appear as if we were in full attendance here.

Your important words will be just as important as if the members were all up here on the rostrum.

I very much regret that this happens in congressional committees, but it is one of the facts of life that we have to deal with. I won't apologize further.

Would you prepare to start, Dr. Wenzlau?

STATEMENTS OF THOMAS WENZLAU, PRESIDENT, OHIO-WESLEYAN UNIVERSITY; SARAH E. KLEIN, PRESIDENT, NATIONAL SCIENCE TEACHERS ASSOCIATION; SAUL FENSTER, PRESIDENT, NEW JERSEY INSTITUTE OF TECHNOLOGY

Mr. **Wenzlau**. Thank you, Mr. Chairman.

We all know quality is what is important, not quantity.

Mr. **Brown**. I keep telling myself that.

Mr. **Wenzlau**. I would like if I might to perhaps summarize some of my comments and ask that the testimony I have prepared be carried in its entirety in the record.

We thank you very much for this opportunity to testify on the National Science Foundation's budget for fiscal year 1983. I am representing a number of colleges which I will not relate since it is in the written testimony.

Our primary concern is our dismay in the budget proposals for 1983 at the virtual rejection of Federal responsibility for providing resources for scientific education in the United States. In making a case for a Federal role, there are two particular truths that I would like to emphasize.

One is that science education is very much in the national interest. I think there can really be little argument about this, that our historic economic and political strength here in the United States has grown out of a well-educated and talented population which has been coupled with technological superiority over other nations.

These attributes are not historical accidents. They have come as a result of great foresight on the part of our decisionmakers who in the past have established the highest priorities for programs leading to education and particularly science education. More recently, other countries seeking to emulate our success, especially Japan, West Germany, and the Soviet Union, have sought to follow our good example and have put massive investments in resources in education and in science education and for research and development.

I needn't remind you about their conspicuous success in challenging our leadership and, in some cases, I think if we were completely accurate we would have to agree that we may have lost that leadership position already. A report on science and engineering education recently prepared by the Congressional Research Service for the House's own Armed Services Committee outlines some very serious shortcomings in U.S. science programs.

One committee member observed, and I quote:

> The United States has depended on a technological edge for both our economic security and national defense for a good number of years. If we can't produce the personnel to operate the technical equipment on which we currently depend, and to develop new innovations for both commerce and defense, we will not only be jeopardizing our economic well-being, we will be endangering our national security.

We would simply argue that if the United States is to maintain a position of technical and scientific leadership in this world during the next century, we must not fall behind now. Producing top-rated research scientists is at least a 10- or 15-year project. I think the delay that has been proposed by Mr. Slaughter and others in their testimony this afternoon in science education programs is simply not an acceptable answer for this country, especially when it is those very persons to whom we are looking for leadership in science education.

Further, it is patently unreasonable in my view to contemplate State or local responsibility for maintaining national technical and scientific superiority for this country. There are only pitfalls and inefficiencies, not advantages, in even contemplating splitting scientific work into 50 units. Although we have not been uncritical of the NSF over the years regarding its efforts in science education, we firmly support the NSF approach because it has demonstrated persuasively that it is an effective vehicle for advancing science.

It has brought education and research together, recognizing their interdependence. It has concentrated competition from the best minds across the entire Nation for research grants, and similarly, it has required schools, colleges, and universities who seek NSF support to compete for funds in a national arena.

It would be naive and inappropriate in our view not to recognize that resources and human talent are a national resource. To be utilized effectively and efficiently, these resources must necessarily be recognized and combined within a national scheme. No State or local subdivision should or can be expected to consider technological and scientific superiority of the country as a high priority objective in determining the allocation of its resources on a State or local basis.

Technological superiority is a national interest, and it will be achieved only if our National Government continues to accept that responsibilty and use it as a critical ingredient of national strength.

The second point is the mutual dependence on interdependence of science education, research, and technology. The quality of our technology and scientific knowledge will depend upon the innate qualities and the education of those human beings engaged in research and in developing technology from that knowledge. Quite simply, high quality research and technology cannot occur without a carefully crafted, adequately financed base of science education.

Since the very beginning of the National Science Foundation, Congress recognized explicity that interdependence. In 1950 the legislation which created the Foundation charged it, and I quote: "To develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences."

In 1972 Congress again reiterated that dual responsibility in Public Law 92-327. Again, I quote: "It authorized and directs NSF to initiate and support basic scientific research potential and science education at all levels."

I would like to have had the opportunity to remind Director Slaughter of the dual relationship given that he was talking about there being no sacrifical lambs in this budget. It seems to me that science education is very much a sacrificial lamb in the budget proposed by the Foundation. But, consistently, since the initiation of NSF, Congress has exhibited this understanding of interdependence.

You have recognized that they provide together essential knowledge and manpower to meet the specific scientific problems this country faces, whether it be space technology, as in the 1950's, the energy crisis in the 1970's, or our national efforts to regain technological superiority as we look ahead to the 1980's and beyond.

In the past this committee particularly has been responsive to the dual responsibility for education and research in the NSF mandate. Its legislation allocated funds to science education when, as again this year, the agency has neglected it. We hope you will not accept the OMB and the budget decision to eliminate these valuable programs in fiscal year 1983.

Strong scientific education requires commitment of resources to science education at all levels.

I would have to say, having listened to the testimony this afternoon in which there was considerable consideration of precollege, and a greater consideration of postcollege, that there was a missing middle.

Fortunately for me, that missing middle is the undergraduate education. There is simply no way that precollege or postcollege scientific education can go on and take place without an equally strong undergraduate program which is linking those two, because it is from the cadre of undergraduates that come the teachers for the elementary and secondary schools.

It is where hundreds of young scientists originate who fill many positions in industry and commerce. Of course, it is out of these undergraduate programs that all graduate students come who specialize in research and ultimately become the research scientists that are so crucial to this Nation.

In spite of this critical role in developing research and in spite of congressional directives, the decisionmakers at OMB and at NSF have rejected, ignored, or down-played that role. Resources for science education which were once almost half of the entire NSF budget have been systematically reduced during the last 15 years to now less than 2 percent of that total NSF budget.

For 1983, with increasing emphasis on cutting expenditure generally, Federal authorities have virtually abandoned scientific education. In allocating a miniscule amount of science education funds for 1983, the Foundation has persevered only in the area of graduate school fellowships.

We think this vision is myopic both by the executive branch and by the NSF and will lead inexorably to second and third-rate science in U.S. schools and colleges in a relatively short period of time.

Predictably, the quality of research and technology will depreciate, and with equal predictability we will find ourselves rapidly becoming a second- or third-rate nation in the world's economic and political arenas.

We implore Congress to restore science education as a priority responsibility of NSF and, ultimately, to implement that priority by mandating that NSF maintain a reasonable relationship between science education spending and its total budget.

Even if Congress approves a slow-down in Federal spending, some funds are necessary to keep in place a national science education effort. Although NSF claims to be committed to a national leadership role in science education, its budget request belies this. Lip service is not enough to slow the national decline in scientific illiteracy as demonstrated by the national assessment of educational progress and scholastic aptitude test scores.

We look to you to require NSF's commitment to excellence in science education, by setting a science education budget which includes more than simply graduate fellowships. To avoid these annual bouts over education cuts, we hope that you will consider a plan to maintain the mutually supportive relationship between science and education and research.

Some reasonable relationship between the two must be maintained. We have suggested requiring $1 of budget for science education for every $2 to be spent for NSF research, roughly one-third of the NSF budget to go to programs which will provide the undergirding for the highest quality research and intelligent logical development.

I hope this argument is not interpreted to mean that we are not supportive of research. We recognize that basic research is vital. Nonetheless, we would urge you to restore an appropriate balance between resources directed to science education and those going to research. A bit more specifically we would urge the committee to recognize in specific report language the importance of continuing to support quality small-scale reseach projects.

Many important discoveries in the history of this Nation have come from small projects carried out by a single researcher with modest equipment needs and an equally modest budget. These sorts of researchers reside on college and university campuses of all sizes all over the Nation. They are concentrated in some disciplines more than others, but there is a great and largely untapped potential for important scientific contributions in this area. It is so easy for these small kinds of projects to be forgotten with the emphasis on big science.

Big science requires teams of researchers and massive costly equipment and, of course, many dollars. Understandably, big science can be accompanied only at Government research centers and in industry and large university campuses. Specifically, we would like to urge the committee to emphasize the support for high quality small research projects.

What constitutes a small research varies from discipline to discipline. But we think appropriate language can be developed to accord priority to maintaining a reasonable balance. The modest 2- and 4-year college research instrumentation program has over the last 2 years been effectively administered, and has encouraged research on our campuses.

Without reservation of resources for instrumentation, these institutions have difficulty competing for funds. We urge that you support no less than the fiscal 1981 level of $2.8 million for that particular project, as well as continued separate administration and review processes for this program, which will guarantee it will not become lost among the big science programs.

In the area of science education specifically, we reiterate that we deplore OMB and NSF actions to eliminate science education funding. We hope you will act to restore a semblance of balance between scientific research and scientific education spending within the NSF budget.

With an emergency budget we believe a reduced staff of NSF science education experts could maintain an effort to promote excellent science education in the following broad categories:

First, personnel support. This would include opportunities for undergraduate student researchers and undergraduate student science faculty and secondary school science teachers.

Second, instructional scientific equipment. Obsolescence continues to be a vital problem in equipment that was acquired, much of it under earlier NSF grants to our institutions.

Third, course improvement to encourage new and improved undergraduate science courses, either single course, departmental or divisional, and course and materials for secondary schools.

We base these recommendations upon a survey of scientists and social scientists at selected undergraduate institutions for whom I am speaking.

In summary, we believe the stringent budget for the science education program will be sorely inadequate to meet the needs of this country. However, it will at least keep in place the effective machine that revolutionalized science education in our country following the Sputnik launching some years ago.

We thank you for your support and I will be pleased to try to answer questions later if you have them.

[The prepared statement of Mr. Wenzlau follows:]

PREPARED STATEMENT BY DR. THOMAS E. WENZLAU, PRESIDENT, OHIO WESLEYAN UNIVERSITY

Chairman Walgren and Members of the Subcommittee:

Thank you for the opportunity to testify today on the National Science Foundation budget request for fiscal year 1983. I am speaking in behalf of the twenty-six members of the Independent Colleges Office,[1] the 868 members of the National Association of Independent Colleges and Universities, the 214 members of the Association of Catholic Colleges and Universities, the 575 members of the Association of American Colleges and the 1,386 institutions of higher education that are members of the American Council on Education. We are dismayed about the virtual rejection of Federal responsibility for providing resources for scientific education in the United States.

In making our case for a Federal role, let me state several truths which are perhaps self-evident.

UNDERLYING PRINCIPLES

First, National Interest. There can be little argument, I believe, with the claim that the historic economic and political strength of America grew out of a well-educated and talented population coupled with a technological superiority over other nations. These advantages were not historical accidents; they were the result of a heavy investment in both education and in science and technology. With great foresight decisionmakers of the past had established the highest priorities for such programs. In more recent decades, after World War II, other nations seeking to emulate our nation's success followed our proven strategy. Japan, West Germany, and the Soviet Union began to make massive resource commitments to education, to science education, to research and development. I need not remind you of their conspicuous success as U.S. leadership is being challenged on virtually every front. More accurately we must admit that in some areas we have already lost that leadership position.

A report on Science and Engineering Education recently prepared by the Congressional Research Service for your Armed Services Committee outlines serious shortcomings in U.S. science programs. One committee member observed:

"The U.S. has depended on a technological edge for both our economic security and national defense for a good number of years. If we can't produce the personnel to operate the technical equipment on which we currently depend, and to develop new innovations for both commerce and defense, we will not only be jeopardizing our economic well-being, we will be endangering our national security."

If the United States is to maintain a position of technical and scientific leadership in the world during the twenty-first century, we must not fall further behind in that effort now.

Furthermore, it is patently unreasonable to contemplate state responsibility for maintaining national technical and scientific superiority under a new federalism. There are only pitfalls and inefficiencies, not advantages, in splitting scientific research and the development of scientific knowledge into fifty separate units. Although we in education have not been uncritical of NSF decisions regarding science education, we firmly believe the National Science Foundation approach has demonstrated persuasively its effectiveness as a vehicle for advancing science. It has brought education and research together recognizing their interdependence, it has concentrated competition from the best minds across the entire nation for research grants and it has similarly required schools, colleges and universities seeking NSF support to compete for funds within a national arena. It would be naive and inappropriate not to recognize that available human talent and research facilities are a national resource. To be utilized efficiently and effectively such resources must necessarily be organized and employed within a national scheme.

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[1] The Independent Colleges Office is the Washington Office of the Great Lakes Colleges Association (whose members are Albion College, Antioch University, Denison University, Earlham College, Hope College, Kalamazoo College, Kenyon College, Oberlin College, Ohio Wesleyan University, Wabash College and The College of Wooster), the Associated Colleges of the Midwest (whose members are Beloit College, Carleton College, Coe College, Colorado College, Cornell College, Grinnell College, Monmouth College, Ripon College and St. Olaf College) and Reed College.

No state can be or should be expected to consider the technological and scientific superiority of the United States as a high priority objective in determining the allocation of state resources. Technological and scientific superiority is a national interest and will be achieved only if our national government continues to accept that responsibility and views it as a critical ingredient of national strength.

Second, the Mutual Dependence of Science Education, Research and Technology. The quality of our technology and scientific knowledge will depend upon the innate qualities and the education of those human beings engaged in research and in developing technology from that knowledge. Quite simply, high quality research and technology cannot occur without a carefully crafted, adequately financed base of scientific education.

Since the beginning of the National Science Foundation, Congress has recognized explicitly the interdependence of science education and scientific research. In 1950, the legislation creating the Foundation charged it to "develop and encourage the pursuit of a national policy for the promotion of basic research *and education* in the sciences." (Emphasis added.) In 1972, *Congress* reiterated this dual responsibility in Public Law 92-372, which "authorizes and directs" NSF to (in part) "initiate and support basic scientific research potential *and science education at all levels.*" (Emphasis added.)

Consistently since then Congress has exhibited the understanding that in the long run neither can proceed effectively or efficiently without the other. Together they provide the essential knowledge and manpower to meet specific scientific problems—be it space technology in 1957, the energy crisis in 1977 or the national efforts to regain technological superiority in the 1980's.

In the past, this Committee has been especially responsive to the dual responsibility for education and research in NSF's mandate. The Committee has legislated funds to science education when, as again this year, the agency has neglected it. We hope you will not accept the Office of Management and Budget decision to eliminate these valuable programs in fiscal 1983.

Strong scientific education requires commitment of resources to science education at all levels. Quality research and technology begin with quality science education in elementary and secondary schools. Undergraduate institutions form a crucial link in this chain leading to scientific excellence. From this cadre of undergraduates come the teachers for the elementary and secondary schools, come hundreds of young scientists who fill the many positions in scientific industry and commerce, come the graduate students who specialize in the research that ultimately will retain or return scientific superiority to the United States.

In spite of this critical role of science education in developing research, in spite of Congressional directives, the decision makers at OMB and at NSF reject, ignore or downplay that role. Resources for science education, once almost half of the total NSF budget, have been systematically reduced during the last fifteen years to less than two per cent of that budget. (See Appendices A and B.) Now, for 1983, with increasing emphasis on cutting expenditures generally, Federal authorities have virtually abandoned scientific education. In allocating a miniscule amount of Science Education funds for fiscal 1983, National Science Foundation administrators have preserved only the graduate school fellowships. This myopic vision by the Executive Branch and by NSF will lead inexorably to second- or third-rate science in U.S. schools and colleges in a relatively short period of time. Predictably the quality of research and technology will depreciate. With equal predictability, we will find ourselves rapidly becoming a second- or third-rate nation in the world's economic and political arenas.

OUR RECOMMENDATIONS

We implore Congress to restore science education as a priority responsibility of NSF and ultimately to implement that priority by mandating that the NSF maintain a reasonable relationship of Science Education spending to the total NSF budget. Even if Congress approves a slowdown in Federal spending, some funds are necessary to keep in place a national science education effort. Although NSF claims to be committed to a national leadership role in science education, its budget request belies this. Lip service is not enough to slow the national decline into scientific illiteracy, as demonstrated by the National Assessment of Educational Progress and Scholastic Aptitude Test scores. (See Appendix C.) We look to you to require NSF's commitment to excellence in science education by setting a Science Education budget which includes more than graduate fellowships.

To avoid these annual bouts over Education cuts, we hope you will consider a plan to maintain the mutually supportive balance between science education and scientific research. Some reasonable relationsip between the two should be maintained, such as, for example, requiring $1 of a budget for Science Education for every $2 spent for NSF research—i.e., roughly one-third of the NSF budget to go to programs which provide the undergirding for highest quality scientific research and subsequent technological development.

Our argument should not be interpreted to mean that we are not supportive of research. Basic research is vital. Nonetheless, we do urge that you restore an appropriate balance between resources directed to Science Education and those going to scientific research.

FUNDS FOR SMALL-SCALE RESEARCH

We would urge the Committee to recognize in specific report language the importance of continuing support of quality, small-scale research projects. Many important discoveries have come from small projects carried out by a single researcher with modest equipment needs and an equally modest budget. These researchers reside on college and university campuses of all sizes all over the country, concentrated more in some disciplines than in others but with great and largely untapped potential to make important contributions to new scientific knowlege. It is easy for these kinds of projects to be forgotten in the emphasis on big science research, which requires teams of researchers, masses of costly equipment and huge quantities of resources—i.e., dollars. Understandably, big science can be accommodated only at government research centers, in industry or on large university campuses.

To insure that some funding is available for small-scale research grants, we have two specific recommendations:

We urge the Committee to emphasize the importance of support for high-quality, small research projects in the NSF basic research budget. What constitutes small research varies from discipline to discipline, but we think that appropriate language can be developed to accord priority to maintaining a reasonable balance for small-scale research in the several fields of science within the National Science Foundation.

The modest Two- and Four-Year College Research Instrumentation Program has, in the last two years, been effectively administered and has encouraged research on our campuses. Without reservation of resources for instrumentation, these institutions have difficulty competing for funds. We urge that you support no less than the fiscal 1981 level of $2.8 million, as well as separate administration and review process for this program to guarantee that it will not become lost among NSF's big science priorities.

SCIENCE EDUCATION

We reiterate that we deplore OMB and NSF actions to zero out Science Education funding. We hope you will act to restore a semblance of balance between scientific research and science education spending within the NSF budget. Within an emergency budget, we believe a reduced staff of NSF's science education experts could maintain an effort to promote excellent science education in the following broad categories:

(1) Personnel support, including opportunities for undergraduate student researchers, undergraduate science faculty and secondary school science teachers;

(2) Instructional scientific equipment and

(3) Course improvement to encourage new and improved undergraduate science courses, either single, departmental or divisional, and courses and materials for secondary schools.

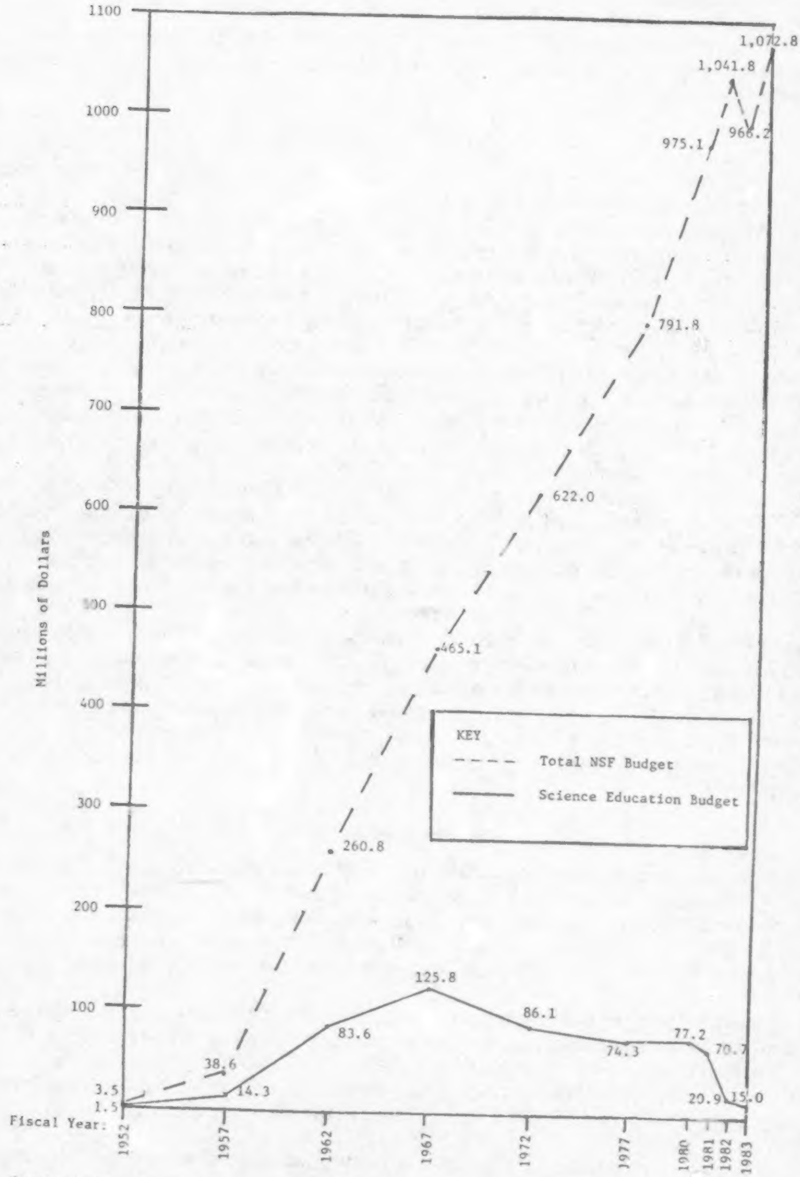
We base this recommendation upon a survey of scientists and social scientists at selected undergraduate institutions.

We believe this stringent budget for the Science Education program will be inadequate to the needs of the nation. However, it will at least keep in place the effective machinery that revolutionized science education in our country after the Soviet Sputnik launching.

I thank you for this opportunity to present our views and concerns to this Subcommittee. I will be pleased to try to respond later to any questions you may have.

Appendix A

Comparison of
NSF TOTAL BUDGETS AND NSF SCIENCE EDUCATION BUDGETS
Five-Year Intervals Fiscal Years 1952-1977 and 1980-1983
(Millions of Dollars)



Sources: "Total NSF Obligations and Obligations for Education in the Sciences FY 1952-1979," NSF: AD/SE, 1-12-78.
National Science Foundation Budget in Brief, Revised March 1981
National Science Foundation Budget in Brief, Fiscal Year 1983

Independent Colleges Office
February 1982

Appendix B

NSF Actual and Proposed Budgets, Fiscal Years 1980, 1981, 1982, 1983

	Fiscal 1980 Actual	Fiscal 1981 Actual	Fiscal 1982 Current Plan	Fiscal 1983 Estimate	% Change 1980-83	% Change 1981-83	% Change 1982-83
NSF TOTAL	975.1	1,041.8	996.2	1,072.8	+ 10.0	+ 3.0	+ 7.7
NSF Science & Engineering Education	77.2	70.7	20.9	15.0	- 80.6	- 78.8	- 28.2
NSF Research:							
Mathematics & Physical Sciences	227.0	251.3[1]	267.4[1]	291.9[1]	+ 28.6[1]	+ 16.2[1]	+ 9.2[1]
Engineering	76.6	85.0[2]	90.8[2]	99.7[2]	+ 30.2[2]	+ 17.3[2]	+ 9.8[2]
Biological, Behavioral & Social Sciences	185.7	185.5	176.0	186.7	+ 0.5	+ 0.6	+ 6.1
Astronomic, Atmospheric, Earth & Ocean Sciences	218.1	236.3	240.0	259.7	+ 19.1	+ 9.9	+ 8.2
NSF RESEARCH TOTAL	707.4	758.1	774.2	838.0	+ 18.5	+ 10.5	+ 8.2

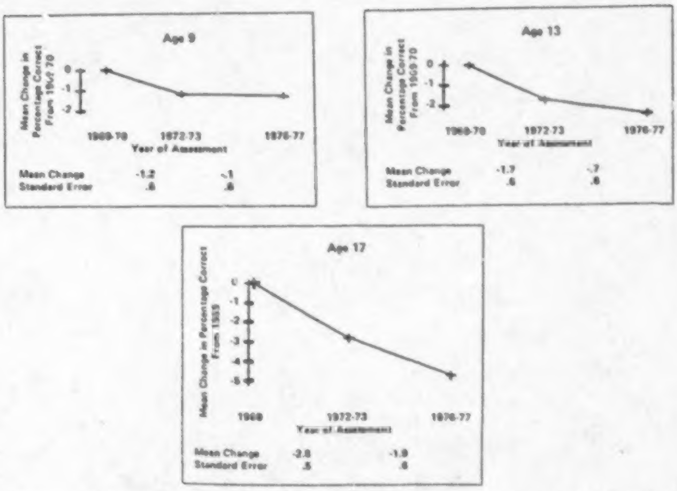
[1] Without program responsibilities transferred to Department of Energy.
[2] Without program responsibilities transferred to U.S. Geological Survey.

Source: National Science Foundation Budget in Brief, Revised March 1981
National Science Foundation Budget in Brief, Fiscal 1983

Independent Colleges Office
2/22/82

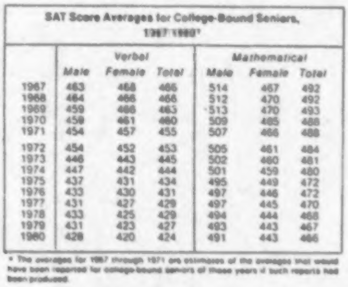
APPENDIX C

Changes in Achievement 1969-1977
Three National Assessments of Science



Source: National Assessment of Educational Progress, Education Commission of the States

Changes in SAT Average Scores for College-Bound Seniors 1967-1980



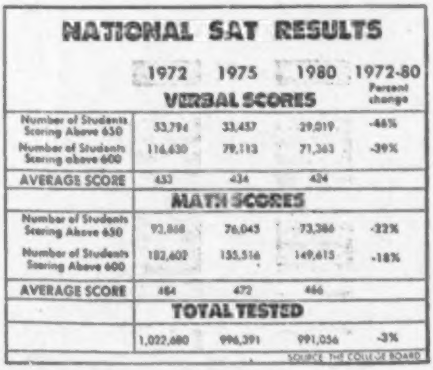
SAT Score Averages for College-Bound Seniors, 1967-1980*

	Verbal			Mathematical		
	Male	Female	Total	Male	Female	Total
1967	463	468	466	514	467	492
1968	464	466	466	512	470	492
1969	459	466	463	513	470	493
1970	459	461	460	509	465	488
1971	454	457	455	507	466	488
1972	454	452	453	505	461	484
1973	446	443	445	502	460	481
1974	447	442	444	501	459	480
1975	437	431	434	495	449	472
1976	433	430	431	497	446	472
1977	431	427	429	497	445	470
1978	433	425	429	494	444	468
1979	431	423	427	493	443	467
1980	428	420	424	491	443	466

* The averages for 1967 through 1971 are estimates of the averages that would have been reported for college-bound seniors of those years if such reports had been produced.

Source: "National Report: College-Bound Seniors, 1980," Admissions Testing Program of the College Board

Changes in Number of High Scores on SAT, 1972-1975-1980



NATIONAL SAT RESULTS

	1972	1975	1980	1972-80 Percent change
	VERBAL SCORES			
Number of Students Scoring Above 650	53,794	33,437	29,019	-46%
Number of Students Scoring above 600	116,630	79,113	71,363	-39%
AVERAGE SCORE	453	434	424	
	MATH SCORES			
Number of Students Scoring Above 650	93,868	76,043	73,386	-22%
Number of Students Scoring Above 600	182,602	155,516	149,615	-18%
AVERAGE SCORE	484	472	466	
	TOTAL TESTED			
	1,022,680	996,391	991,036	-3%

SOURCE: THE COLLEGE BOARD

Source: "Number of High Scores on College Board Exams Drops Dramatically," The Washington Post, March 2, 1981, page B1.

Mr. **Brown**. Thank you very much, Dr. Wenzlau.

That is a very forceful statement and contains a lot of very good suggestions for programs.

I will recognize the other members of the panel before we ask questions, however.

Ms. Klein?

Ms. **Klein**. Thank you.

Mr. **Brown**. Ms. Klein is president of the National Science Teachers Association. You may be the first real practicing science teacher we have had here.

Ms. **Klein**. I am a rare breed.

Thank you very much, Mr. Chairman and members of the committee, for the opportunity to testify in regard to the crisis in science education.

I have written testimony and would submit it for the record.

Mr. **Brown**. Without objection, it will be made a part of the record in full.

Ms. **Klein**. Thank you.

My verbal testimony will be much more informal and really will just be highlights of the written testimony.

As an eighth grade science teacher in middle school, I feel maybe that I have not been "the lamb that was led to slaughter." I feel like maybe a ewe that has been well-pummeled over the years. Nevertheless, a stated fact is, without the National Science Foundation, there are many of us that would not have had all of the science that we have needed over these, well, I don't want to say how many years.

I feel a tremendous responsibility, because I am speaking on behalf of all of those teachers that did receive some training, some education through the National Science Foundation. I firmly believe that all of these programs that the National Science Foundation did support were an investment in our future today, just as they must be an investment in our future tomorrow.

I suspect if we were to go back and investigate specifically the effects of a few programs within the last few years sponsored by NSF, we would find that some of this crisis today could have been eliminated if we would have had more direct and more specific courses for teachers in the field today.

We have some very dramatic points that we feel are made in our testimony. I am just delighted that Dr. Wenzlau pointed out the real reason for the Foundation, and that is to initiate basic support for scientific research programs and also the research potential and science education programs at all levels.

I don't have to requote that, because it is there and this is the reason why we are so concerned. If science education is to be taken out of the NSF budget, then maybe we need to go back to Congress and ask Congress to redo that basic act because without this, the real force directed to teachers, then NSF really is not assuming the responsibility that they should have.

I feel that the commission that they are recommending is certainly well placed. It comes at a time when we do need to think about doing something for a long-range plan and a long-range program. No one can deny that.

But, I feel that we must look at the things that have been effective. Everyone wants to be a part of a winner and a winning team. No one likes to be a loser. Therefore, I think that NSF has been a winner with programs that have helped so many people and so many teachers to feel confident. I feel NSF really must take a firm look at the direction in which they are going today.

I think I can speak not only for myself but, again, for many others. My degree is in home economics. The majority of us know that to be able to participate in a home economics program, one must have a great deal of science background. But when one takes time out to have a family, to teach home economics, or even think of going into the science field, one must think of updating that science.

Without updating courses, we do not have the credibility for the teaching profession that we need. I think we point to that in our statistics and in our charts. We have listed several problems, and one of the problems that we have listed is the lack of certified science teachers and mathematics teachers at the secondary level.

We could certainly get science and mathematics teachers that we need if we could get some of these NSF-supported courses to these existing teachers that would help give them the confidence that they need to be able to teach the science and the math. Science and math teachers, as we also point out, are leaving the fields of science teaching in droves. We have statistics that show that.

I hestitate to quote statistics again. At this time of day, who needs another statistic? Nevertheless, I urge you to look at the findings that we have, because these teachers, the potential teachers may be there. But without the confidence of some in-service training and some course work, we are going to be lacking, not only at the present time, but in this electronic age.

We really are in this electronic revolution, whether anyone really wants to admit it or not, it is here. As an eighth grade teacher, the first day back after a Christmas vacation, the only thing to do is play those electronic games and find out the science behind them. We do a lot more teaching about electronic sciences today than perhaps we ever thought of doing previously.

Nevertheless, we must be aware that there are critical shortages of physics, mathematics, and chemistry teachers at the secondary level. We would love to have many students that we could encourage to go on to that undergraduate level. Without proper teachers at the precollege level, we just don't have the people that will keep these students encouraged.

It's a well-known proven fact that the earlier you begin to study something and learn something, the longer it stays with you, the more you want to learn, the more you can progress. Therefore, science at the elementary level is imperative.

Our point No. 5, on page 9, I do have to go to that because elementary and secondary schools need access to microcomputers and low-cost supplies and other resources. I think perhaps if we could get everyone to agree that that is where the thrust is, I don't believe communities would really object to supplying funds if they felt that those computers were going to be useful.

Where could teachers be trained? Through NSF programs. We must encourage funding for updating of courses for the elementary schools, the elementary teachers, as well as for those middle school and secondary teachers.

The other thing that I think we have to be aware of is that these new sequences for science and math, I think it was Dr. Rutherford that pointed out that with very little extra training or additional cost, that training could be done for these teachers.

Therefore, I feel very strongly that this could be done at a cost that could be well within some limits. The other thing that I think I really must point out from our written testimony, and I quote: "The administration's proposed NSF budget calls for a total of $1,072,800,000 in 1983, an increase of 7.7 percent over 1982. The needed science education programs would be financed by holding the total research and related activities budget to a 2 percent increase instead of an 8.7 percent increase, which is proposed. This will free $85.5 million for science education activities."

Maybe this is the answer to our resources, and maybe this is the answer that we have been looking for. On that page also we have pointed out that with the NSF science and engineering education recommended program component for 1983 we think that we could help 100,000 people with NSF funding for 1983.

Thank you very much.

[The statement of Ms. Klein follows:]

PREPARED STATEMENT OF SARAH E. KLEIN, PRESIDENT, NATIONAL SCIENCE TEACHERS ASSOCIATION

The following testimony is presented by Sarah E. Klein, President of the National Science Teachers Association (NSTA). The NSTA is the largest science education organization in the word. It is the only science education organization that is concered with the professional aspects of science education at all levels and for all science disciplines.

Mrs. Klein is an 8th grade general science teacher at Roton Middle School, Norwalk, Connecticut. She is currently on leave to carry out her responsibilities as President of NSTA. Mrs. Klein has been active in NSTA for many years, and over the past year has visited schools, talked to teachers, and participated in numerous science meeting throughtout the United States, Canada, England, and France. Mrs. Klein wishes to acknowledge the efforts of Bill Aldridge, Executive Director of NSTA, and of James Shymansky, of the University of Iowa, in the documentation and preparation of this testimony

THE DUAL MISSIONS OF THE NATIONAL SCIENCE FOUNDATION

The dual missions of the National Science Foundation are to strengthen the scientific research and science and engineering education capabilities of this nation.

"The Foundation is authorized and directed (1) to initiate and support basic scientific research and programs to strengthen scientific research potential and science education programs at all levels . . ." (NSF Act of 1950).

Since 1959, when the science education component of NSF accounted for about one-half of the entire NSF budget, the science education share has been systematically reduced to its low of 7.5 percent in 1980. With the budget proposal of March 10, 1981, the OMB began a process which would totally eliminate programs of the science education component of NSF, thereby changing the mission of this agency from its dual purposes of strengthening scientific research and science education to just research.

Of the $20.4 million appropriated for NSF science education for 1982, $15 million was for graduate fellowships. Some $700,000 was designated to support a "commission," and the balance was used to meet "prior obligations."

Staff of the Science Education Directorate have already been reduced from over 100 to about 50, and within the next few months, will be reduced to 10 or 12 persons. Since graduate fellowship support is but another form of support for scientific research, the NSF has essentially eliminated all science education activities. The Administration has successfully forced NSF to abandon one of the missions required by its enabling legislation. It is time that NSF either ask Congress to change the organic act and delete science education from its mission or stop the deception that graduate student support alone is somehow equivalent to support of science education at all levels and proceed with its responsibilities by providing a budget which addresses serious national problems in science education.

THE SPECIAL COMMISSION ON SCIENCE AND ENGINEERING EDUCATION

The only new activity for science education in the 1982 budget was $700,000 to support a special commission on science and engineering education. The draft charter for this commission would have it duplicate studies already undertaken, but largely ignored. The NSF spent upwards of $3 million over the past five years for such studies. There already is ample evidence of what the problems are and what is needed to solve them. The problems are not solved by additional studies. What is needed is federal action to address documented and serious national problems. A major problem, like the crisis in secondary science education, which is national in scope, cannot be broken into 50 smaller problem prices and sent back to the states to solve. Both the commission charter and the National Science Board Policy statement that brought the commission into existence specifically recognize that NSF programs could result from work of the commission. However, the proposed 1983 budget has no funds to act on recommendations of the commission. Indeed, there are not evern funds to continue the commission itself. One can only conclude that this commission is but another gratuitous, empty gesture toward meeting NSF's obligations to science education.

THE CRISIS IN SECONDARY SCHOOL SCIENCE AND MATHEMATICS EDUCATION

Our nation faces unprecedented problems in science and engineering education. Most severed of these problems are at the secondary school level where there is a critical shortage of qualified science and math teachers. The paucity of supplies, resources, appropriate materials, and support have reduced the quality of science and math education at the secondary school level to a point that national security and the nation's efforts toward improved productivity are dangerously threatened.

SHORTAGES OF SECONDARY SCHOOL SCIENCE AND MATH TEACHERS

In 1980 and again in 1981, surveys were conducted by Howe and Gerlovich (1) of the 50 state science supervisors to assess supply and demand for secondary school science and math teachers. Shortages of science and math teachers were found to exist in 1980, and those shortages became more severe in 1981. As shown in Table I, this problem is national in scope, and the shortage are critical in physics, mathematics, and chemistry.

TABLE I.—NUMBER OF STATES REPORTING IN 1980 AND 1981

Subject	Critical shortage		Shortage		Adequate supply		Surplus	
	1980	1981	1980	1981	1980	1981	1980	1981
Physics	21	27	22	15	3	4	2	1
Math	16	18	19	25	7	2	4	1
Chemistry	10	9	25	29	9	6	5	2

Another survey of placement officers conducted by James Akin (2) in 1980 showed similar results. "Considerable shortages" of teachers were found for math, Physics, chemistry, and general science.

SEVERE DECLINE IN NUMBERS OF PERSONS PREPARED TO TEACH SCIENCE AND MATH

In December, 1981, the NSTA surveyed 600 colleges and universities that have teacher training programs (3). We wanted to find out what has been happening to numbers of newly trained science and math teachers. Year-by-year data were acquired for the ten-year period of 1971-1980. The results shown in the appended graph No. 1 are shocking. There was a 78 percent decline in the average number of math teachers and a 64 percent decline in the average number of science teachers prepared to teach in secondary schools.

EMPLOYMENT OF UNQUALIFIED SCIENCE AND MATH TEACHERS

In another NSTA survey (4), also conducted in December, 1981, and analyzed by James Shymansky of the University of Iowa, secondary school principals provided the information. Among newly employed science and math teachers, 50.2 percent were unqualified to teach science or math. They were employed on an "emergency basis" because no qualified teachers could be found. When these data are examined by census regions, the results are especially bad in states where high technology industries require the best trained science and math personnel. Table II shows, by census region, the percentages of newly employed science and math teachers last year who were unqualified to teach these subjects.

Table II.—Percentage of newly-employed science and math teachers who were unqualified

Census region:	*Percent*
Pacific States	84
Mountain States	23
West North Central States	43
West South Central States	63
East North Central States	46
East South Central States	40
North East States	9
Atlantic States	43
South Atlantic States	50

AGES, EXPERIENCE, AND PLANS OF SCIENCE AND MATH TEACHERS

The evidence of a severe shortage of science and math teachers at the secondary school level is overwhelming. To compound this problem, results of the NSTA survey of science teachers show that schools have an aging faculty and that one in four of the younger faculty plan to leave teaching completely. The average age is 41, and the average experience is 16 years. Almost 5 times more science and math teachers left teaching last year for employment in non-teaching jobs than left due to retirement.

CONCLUSIONS ABOUT TEACHER SHORTAGES

Independent recent surveys all show a severe shortage of secondary school science and math teachers. There has been a catastrophic decline in the number of persons prepared to teach science and math, and of those prepared, many do not take teaching positions. Secondary schools are employing record numbers of unqualified persons for science and math teaching positions because qualified persons cannot be found. The problems are most severe in regions of the country where the greatest efforts will be made for defense preparedness and high technology industry. Thus there is a dangerous mismatch between scientific and technological training capability and national need.

QUALITY OF SCIENCE AND MATHEMATICS EDUCATION

The severe shortages of secondary school science and math teachers, and the resulting employment of unqualified teachers on an emergency basis is a major factor in the decline of quality in secondary school science and math education. For the teachers who remain in the science and math classroom, there are other constraints which have made the situation deteriorate further.

From the recent NSTA survey, we know that 60 percent of the science teachers report cuts in their budgets for supplies and equipment. These cuts occur at a time when school labs are already obsolete, and when computers and other components of modern electronics are essential in an up-to-date curriculum.

From the same survey, we learned that 79 percent of these teachers had not completed at least a 10-hour course or workshop in over ten years. Also, 69 percent have never attended a computer course or workshop. Finally, 40 percent have not attended a course or workshop since they began teaching, an average of 16 years.

In another recent national survey conducted by NSTA, *elementary* school teachers provided the responses (5). Approximately 51 percent report that their undergraduate training did not give them *any* preparation to teach science. Furthermore, 71 percent have never had inservice training for science, and 64 percent no longer had science consultants assigned to their schools.

There has been much public discussion of declines in SAT scores, but less attention has been given to declining scores in the national assessment. There has a been a decline in recent years, and now those declines are affecting even our best science and math students.

PRIOR NSF SUPPORT OF SCIENCE AND ENGINEERING EDUCATION

There is, among those in the Administration, and among many others, the mistaken belief that science education has received substantial support, especially in recent years, and that since we now see all of these serious problems, the infusion of massive federal support has been a failure. The facts are quite the opposite. The NSF support for science and engineering education has been declining steadily and steeply for the past 22 years. The appended Graph No. 2 shows how science education's share of the total NSF budget has dropped from a high of 47 percent in 1959 to its present low of 2 percent.

Support for pre-college science education has dropped even more sharply, from 72 percent of the science education budget in 1959 to 22 percent in 1980. In terms of the total NSF budget, the pre-college share has dropped from 34 percent in 1959 to its present low of less than 1 percent.

The NSF support for secondary school science and math has fallen to a negligible level, and the present cluster of national problems in secondary school science and math education can in large part be attributed to NSF's negligence of this component of their Congressionally mandated mission. The appended Graph No. 3 shows how the decline in NSF support at the pre-college level correlates with declining achievement in science as measured by the National Assessment of Educational Progress.

NSF CURRICULUM DEVELOPMENT PROJECTS

Much of the demise of NSF's science education support has resulted from criticisms of curriculum development activities.

There are legitimate criticisms that one can make of the "new curricula" produced under NSF support: These projects often purged applications, concentrated heavily on pure science, and appealed mainly to the brightest students. Their difficulty level contributed to the reduction in the numbers of students studying science and mathematics in recent years.

According to preliminary results of a very recent study (6), the new curricula were far more successful than most people realized. In this NSF-supported project (SED 80-12310), directed by Ronald Anderson of the University of Colorado, and carried out by James Shymansky of Iowa, an analysis was made of 105 studies involving 45,000 students. Comparisons were made between students enrolled in new science curricula and traditional curricula. On every kind of measure, including achievement, attitude, and process skills, students taking the new NSF curricula scored overall 13 percent higher. For the BSCS Biology and Chem Study materials, the students scored higher by more than 17 percent. What is most significant is the fact that students from low socio-economic groups scored 23 percent higher using new NSF-supported curricula than traditional curricula. Thus, since a larger proportion of our minority population are in the low socio-economic categories, the new curricula, supported by NSF, gave minority children a decided edge over similar children exposed to traditional materials.

These studies covered a period of several years in the 1960's and 1970's. Few teachers are left in the schools now who are qualified to teach such curricula, and essentially none have been given the in-service training to do so since NSF abandoned that kind of program several years ago. Also, the materials are badly in need of revision and modification to take into account computers, modern electronics, and applications to technology. The problem of offering appropriate science to less able children also must be addressed.

COMPARISONS OF U.S. AND U.S.S.R. SCIENCE AND MATH EDUCATION

Recent comparative studies (7) in science and engineering education between the Soviet Union and the United States suggest a major offensive by the U.S.S.R. to increase its economic productivity and defense preparedness through science and engineering education. The U.S.S.R. offers its precollege students sequences of course material in science and mathematics starting with an intuitive level of understanding. Then students progress to empirical levels; finally, they are ready for the formal axiomatic and theoretical understandings. The actual time spent begins with only a couple of hours per week and changes gradually over three or four years until students spend four to five hours per week in class. Thus the Soviets not only offer all students quantitatively more contact with the sciences and mathematics, they do so systematically to ensure that students progress in a way that matches stages of intellectual development. In U.S. secondary schools, and in colleges, students enter a course in physics or chemistry and are immediately introduced for the first time to the highest levels of abstraction, without any intuitive basis or prior empirical knowledge. Thus many find these subjects hopelessly difficult and fail or drop out. Most students simply avoid taking these subjects, having heard how difficult they are. The lack of application in science curricula and their failure to relate to personal and societal problems and issues further alienate students.

AN NSF SCIENCE AND ENGINEERING EDUCATION COMPONENT FOR 1983

Given clear and conclusive evidence of serious national problems in science and engineering education, what specific programs can the NSF undertake in 1983 within the constraints of the proposed budget?

The most critical problems are at the pre-college levels, especially in secondary school science and mathematics. Those problems are, in order of priority:

(1) Critical shortage of physics, mathematics, and chemistry teachers at the secondary school level;

(2) Substantial numbers of unqualified persons are teaching science and mathematics in secondary schools;

(3) New sequences of science and math courses and materials are needed which match stages of intellectual development of children;

(4) Even certified science and mathematics teachers at the secondary level are badly in need of in-service training;

(5) Elementary and secondary schools need access to microcomputers and low-cost supplies and other resources;

(6) Science curricula need revision, and teachers need training in using new materials and new methods of sequencing content; and

7. Elementary school science consultants are needed who understand science, stages of intellectual development of children, and who know what resources are available.

The critical shortage of secondary science and math teachers cannot be solved in 1983. This problem is closely related to the problem of unqualified and marginally-qualified teachers who are now teaching science and mathematics. Because there are overall reductions occurring in the numbers of teachers needed in some other fields, many of the newly-appointed, but unqualified science or math teachers are recruited from these other areas.

The long-term shortages must be addressed by stimulating new entrants to teacher training programs in science and mathematics. This can be accomplished through NSF scholarships and NSF-supported programs of publicity on the need for teachers.

In the short term, the NSF should support summer and academic-year courses and workshops for marginally-qualified science and math teachers, so that they may reach some minimal level of qualification to teach the assignments they have been given. The level of support should be limited to grants for tuition, books, and materials, up to a maximum of 20 semester hours' credit equivalent per year. No support should be given to colleges for this program, since the tuition grants provide indirect support and cover the costs of that instruction.

The problem of establishing new sequences of science and math courses to math the stages of intellectual development of children is most difficult to solve.

The most cost-effective solution would be for the NSF to support development and implementation of a model sequence in two or three school systems. These models would be carefully developed in cooperation and with assistance of scientists and science education experts at universities. Detailed guidelines for establishing the sequence would be prepared snd widely disseminated. The NSF would provide support only for consultant services to schools that chose to implement the approach following the guidelines which had been developed.

The problem of upgrading qualified science and math teachers can be solved by offering short courses and workshops. The NSF has models of these already in operation and could easily continue these programs.

The need for low-cost supplies and other resources can be addressed by NSF through a program of support for area Science Instruction Resource Centers, modeled after the one created by Douglas Lapp in the Fairfax, Virginia School District.

Microcomputers could be supplied through an NSF program of partial support. Even a level of support by NSF of 25% of the cost could have great leverage in

bringing larger numbers of microcomputers into the schools. Given the availability of in-service programs for teachers, proper utilization could be assured.

The revision of curricula to bring them up to date and to accommodate to the new technology, applications, and societal problems, can be accomplished through conventional, but carefully monitored, curriculum development projects.

The problems of elementary school science are immense, but a high-leverage approach, with relatively low cost, would be an NSF program of summer and in-service studies for science consultants. Also, some modest grant support could be provided to school districts that were willing to reinstitute a science consultant program for their elementary schools.

Does the American Public Think that Tax Funds Should be Used by NSF to Support Science Education and Basic Research or Just Basic Research?

The Thirteenth Annual Report of the National Science Board, Science Indicators 1980, dated March 31, 1981, offers much interesting and useful information.

The table below is taken from that NSF report. According to this report to the President, the Public would rank science education second as its choice "to receive science and technology funding from tax money." The public would rank basic scientific research tenth in its choice to receive such tax money.

Science education ranked 2nd—Basic scientific research ranked 10th!

Given clear evidence of public preference for spending tax money for science education over spending it for basic research, and given the Congressional mandate in the organic act of NSF to support science education at all levels, it is most difficult to understand why NSF is forced to neglect this responsibility.

APPENDIX TABLE 6-10. AREAS THE PUBLIC WOULD MOST LIKE TO RECEIVE SCIENCE AND TECHNOLOGY FUNDING FROM TAX MONEY: 1972-79

Area	Percent in 1979	Rank[1]			
		1972	1974	1976	1979
Improving health care	50	1	1	1	1
Developing energy sources and conserving energy	46	([2])	([2])	([2])	([2])
Improving education	39	5	[3] 4	[3] 4	2
Reducing crime	36	3	2	2	3
Developing or improving methods for producing food	23	([2])	([2])	([2])	([2])
Reducing and controlling pollution	22	2	3	[3]3	4
Developing or improving weapons for national defense	16	[3]10	[3]11	[3]8	[3]5
Preventing and treating drug addiction	16	4	[3]4	5	[3]5
Developing faster and safer public transportation within and between cities	13	7	7	7	7
Improving the safety of automobiles	9	6	6	6	8
Finding better birth control methods	9	8	9	[3]8	9
Discovering new basic knowledge about man and nature	8	9	8	10	10
Exploring outer space	6	[3]10	[3]11	11	11
Predicting and controlling the weather	4	[3]10	10	12	12

[1] In 1979, respondents were asked to limit themselves to three areas, and slight changes in the wording of some items were made.

[2] "Developing energy sources and conserving energy" was not included in the listing prior to 1979 and "developing or improving methods for producing food" was not included prior to 1976. These areas were therefore omitted from the rankings.

[3] Tied for the indicated rank.

Note.—N = 1,635.

Sources: Attitudes of the U.S. Public Toward Science and Technology. Study III (Princeton, N.J: Opinion Research Corporation, 1976), pp. 56-57; Jon D. Miller, Kenneth Prewitt, and Robert Pearson, **The Attitudes of the U.S. Public Toward Science and Technology** (Chicago: National Opinion Research Center, University of Chicago, 1980), p. 137.

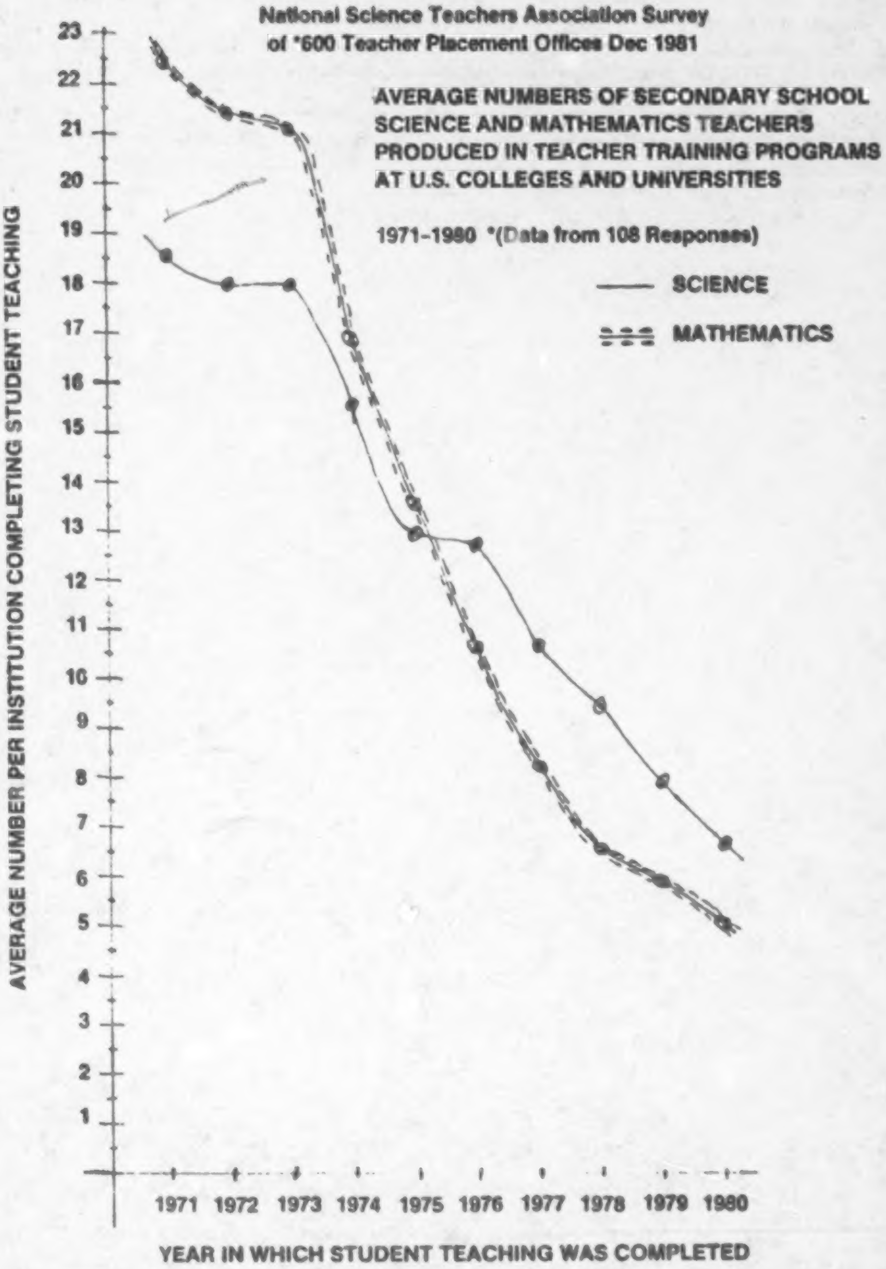
Where are the Funds for Science and Engineering Education?

The Administration's proposed NSF budget calls for a total of $1,072.8 million in 1983, an increase of 7.7 percent over 1982. Needed science education programs would be financed by holding the total research and related activities budget to a 2 percent increase instead of the 8.7 percent increase which is proposed. This will free up $65.5 million for science education activities.

NSF science and engineering education recommended program elements for 1983

	Millions
NSF undergraduate scholarships for math and science teaching (4,000 at $1,500 each)	$6.0
Science and math teaching careers publications and dissemination	1.5

	Millions
Tuition, books, and materials for summer and academic-year courses and workshops (5,000 marginally-qualified teachers at $2,000)	10.0
Model sequences for science and math courses (3 projects at $2 million)	6.0
Short courses and workshops for upgrading qualified science and math teachers (10,000 teachers at $1,000)	10.0
Model science instruction resource centers (50 at $200,000)	10.0
Partial support grants for microcomputers (25 percent of $2,000 for 10,000 schools)	5.0
Curriculum revision and enhancement projects	12.0
Programs for science consultants for elementary schools	5.0
Subtotal	65.5
Graduate fellowships	15.0
Total	80.5

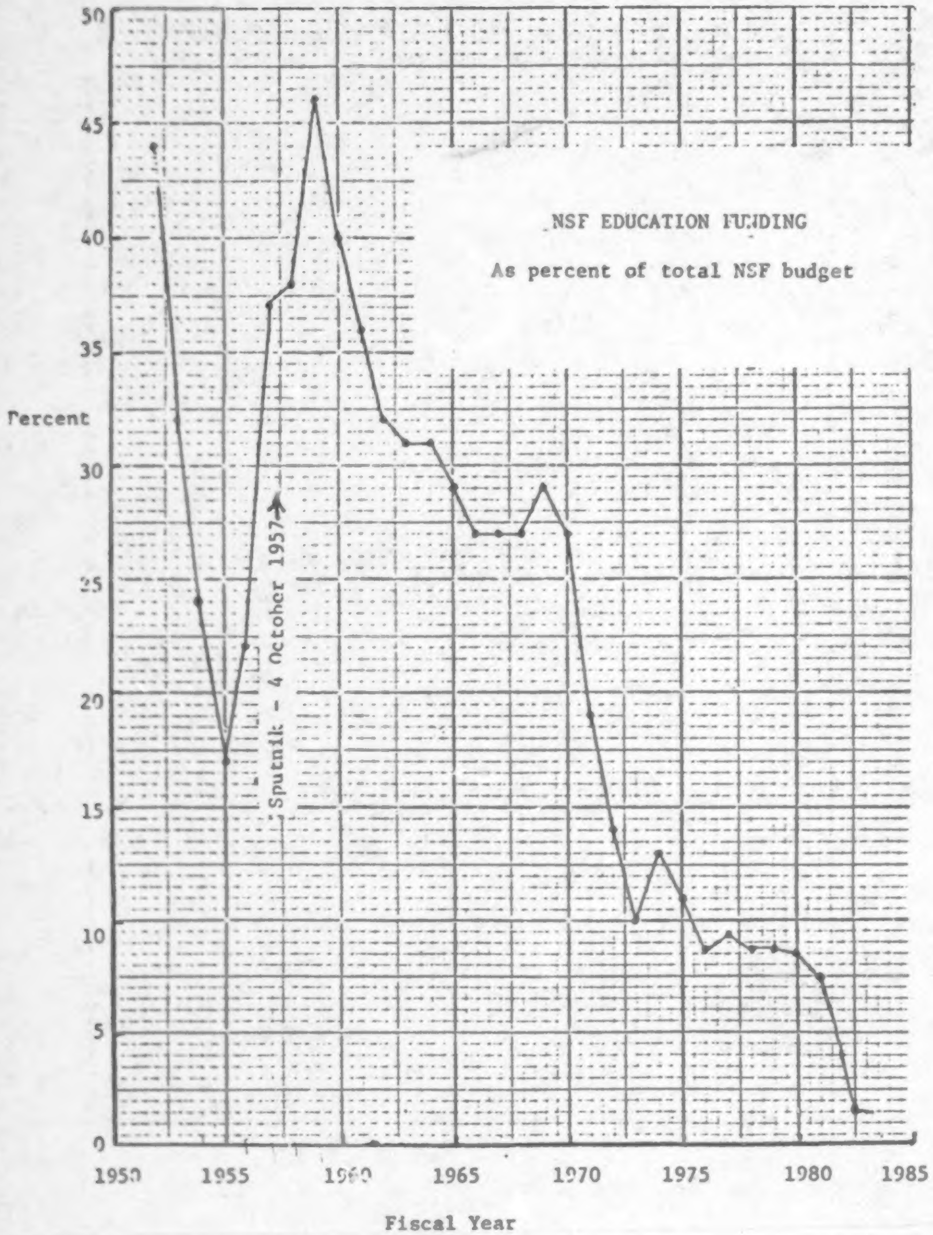


National Science Teachers Association Survey
of *600 Teacher Placement Offices Dec 1981

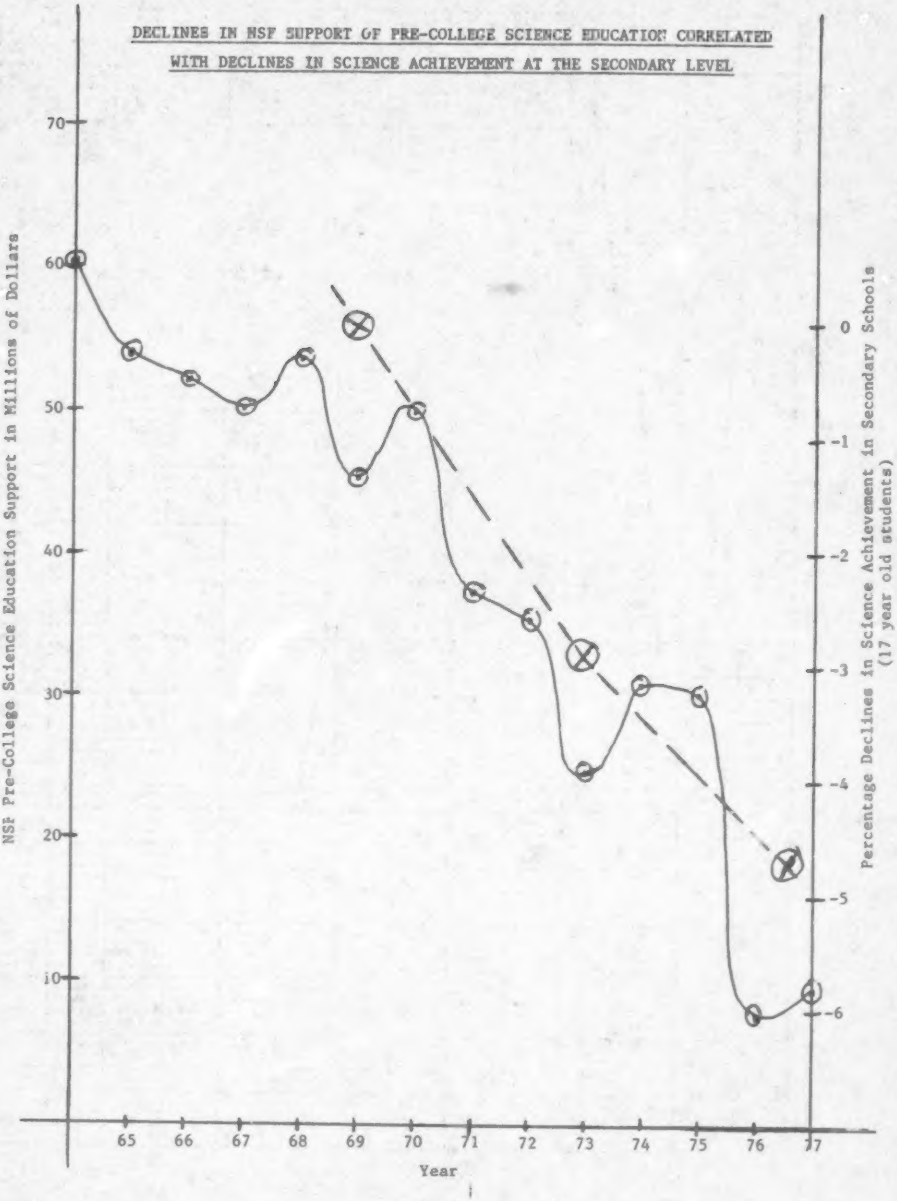
AVERAGE NUMBERS OF SECONDARY SCHOOL SCIENCE AND MATHEMATICS TEACHERS PRODUCED IN TEACHER TRAINING PROGRAMS AT U.S. COLLEGES AND UNIVERSITIES

1971-1980 *(Data from 108 Responses)

GRAPH #1


NSF EDUCATION FUNDING
As percent of total NSF budget
Percent
50
45
40
35
30
25
20
15
10
5
0
Sputnik - 4 October 1957
1950
1955
1960
1965
1970
1975
1980
1985
Fiscal Year

GRAPH #2


DECLINES IN NSF SUPPORT OF PRE-COLLEGE SCIENCE EDUCATION CORRELATED WITH DECLINES IN SCIENCE ACHIEVEMENT AT THE SECONDARY LEVEL
NSF Pre-College Science Education Support in Millions of Dollars
70
60
50
40
30
20
10
Percentage Declines in Science Achievement in Secondary Schools (17 year old students)
0
-1
-2
-3
-4
-5
-6
65
66
67
68
69
70
71
72
73
74
75
76
77
Year

GRAPH #3

SOURCES

(1) T. G. Howe and J. A. Gerlovich, "National Study of the Estimated Supply and Demand of Secondary Science and Mathematics Teachers," Unpublished Paper, Novembver 6, 1981.

(2) J. N. Akin, "Teacher Supply and Demand: A Recent Survey," (ASCUS, Box 4411, Madison, WI 53711) 1980.

(3) Preliminary results of December, 1981, NSTA Survey of 600 Colleges and Universities with science and math teacher training programs.

(4) Random sample of 2,000 U.S. secondary school principals in December, 1981. Analysis done by Dr. James Shymansky using staff and computers at University of Iowa.

(5) Preliminary results of survey undertaken in January, 1982, by Kathleen M. Donnellan, NSTA Preschool/Elementary School Division Director, Springfield, Massachusetts Public Schools.

(6) C. P. Ailes and F. W. Rushing, "The Science Race: Training and Utilization of Scientists and Engineers, U.S. and U.S.S.R.," Chapters I, II, (Crane Russak, New York) 1982.

Mr. BROWN. Thank you very much, Ms. Klein, for an excellent statement.

All right, Dr. Fenster, we have been waiting a long time to hear from you.

Dr. FENSTER. Thank you, Mr. Chairman. Thank you too for your patience.

My name is Saul Fenster, and I am president of New Jersey Institute of Technology, which is the largest technological university in the Metropolitan New York-New Jersey area.

I am pleased to have this opportunity to appear before the subcommittee today to testify on the NSF 1983 authorization bill with particular emphasis on the science education directorate.

Mr. Chairman, I would like to introduce for the record my complete written testimony.

Mr. BROWN. It will be made a part of the record in full.

Dr. FENSTER. Thank you.

I represent the 353 member institutions of the American Association of State Colleges and Universities and speak also on behalf of many associations, as enumerated in my written testimony.

With a combined enrollment of over 2½ million students, the 353 State colleges and universities of AASCU enroll 1 out of 4 of all baccalaureate degree students in the country.

Our institutions play a major role in our Nation's science effort. Many students who ultimately pursue advanced degrees in scientific and technical fields receive their basic undergraduate training at our institutions. A large portion of the Nation's future elementary and secondary school science and mathematics teachers are educated at AASCU colleges and universities.

These teachers must be able to communicate the knowledge and skills that will enable our youth to live in an increasingly complex and technology-dependent society. AASCU institutions award close to 30 percent of the B.S. degrees in engineering annually.

In the past, this subcommittee has been a strong supporter of our Nation's efforts to adequately fund science and engineering education.

I am delighted by your remarks today. Your recommendations on the fiscal year 1982 authorization bill rejected the administration's proposal to terminate science and engineering education programs and suggested guidelines for funding that acknowledged the necessity for fiscal constraints.

I urge you to adopt a similar approach for fiscal 1983.

The past year has been an increasingly bleak and frustrating one for those of us interested in, and concerned with, the future scientific and technological strength of the United States.

The administration's decision to cut funding for all science and engineering education programs, with the exception of the graduate fellowships program, is an example of fiscal considerations, reduced budgets, interfering with perceived national goals, adequate supply of scientific and technological manpower.

I would like to comment on the changing international environment. The proposed cutbacks in funding for science and engineering education come at the very time in our history when the U.S. position in world leadership in science and technology is being severely challenged.

Proposed cuts we believe ultimately will jeopardize our national security and economic well-being by undermining American industry, and commercial and military strength. The severity of the situation was highlighted in a recent study by SRI International that compared the education and employment of scientists and engineers in this country and the U.S.S.R.

Based on its findings, the report concludes:

> that there is a need for concern of the United States and that concern should be manifested in a systematic and comprehensive review of our training of Americans at all levels of education for an increasingly scientific and technological world. Such a review will undoubtedly indicate that changes are required, and we should be prepared to make them. If anything less is accepted as a national objective, then there is cause for alarm.

I would like to cite some examples that cause me to be alarmed about our Nation's future scientific and technological base.

For example, manpower shortages in engineering and computer specialists are contributing to the decline of productivity in this Nation and a decline of our national share of world trade. Between 1963 and 1977, the productivity increased in the manufacturing industries of the United Kingdom by 51 percent, of West Germany by 114 percent, of Japan by 197 percent, and of the United States by only 39 percent.

During that same time, the U.S. share of world trade in manufactured items declined from 21 percent to 16 percent while Japan's share increased from 8 percent to 15 percent.

Another example: The Department of Defense reports that it has problems recruiting and retaining civilian and military engineers. The Air Force reports a shortage of 1,100 engineers. It also notes that it is more and more difficult to find officers and NCO's who are qualified to be trained to operate increasingly sophisticated military hardware. Here again is an example of the strategic connection.

Against this omnious background, our Nation's science and engineering education establishment has been beset with a range of problems. You as well as I know our system of science and engineering education is in a state of crisis. Certainly every speaker here today echoed this and underscored it.

What we lack, however, is a nationwide commitment and agenda to deal with these problems.

To speak for a moment on the role of the NSF in this regard, I strongly believe the NSF must play a leading role in restoring the health of American science education. When the NSF was established in 1950, it was authorized and directed to "initiate and support basic scientific research and programs and science education programs at all levels." This was reiterated just a few minutes ago. The educational mandate of the NSF has been an integral part of our Nation's scientific establishment since that time. The NSF's support of science and engineering has been crucial to my institution. We have discussed today the fact that the present programs may not be perfect, but they have been invaluable to us.

For example, it has provided the initial funding for our center for precollege programs. Mr. Chairman, I have a report of that program which I would like to leave with the committee.

Mr. **Walgren**. Without objection, the report will be made a part of the committee hearing.

[The information follows:]

INTRODUCTION

A decade has passed since New Jersey Institute of Technology offered its first on-campus program for high school students. Whereas in 1971 only 40 students participated, now more than 1,000 take courses, mini-courses and workshops at NJIT. Advances in technology, rapid growth in the fund of knowledge, and a myriad of socio-economic changes have altered the student's view of the world immeasurably in a short span of years. Pre-college program students of the early 70's are now practicing engineers, technologists and computer scientists. They are doctors and attorneys, rising managers and businessmen and women. Several are teachers who send students to the programs. These young people set a high standard of participation and achievement. Their success encouraged the Institute to develop the variety of programs that are offered today.

Pre-College programs of the 80's respond to the times. Problems of our cities have not diminished and the urban environment is very much a focus. Several programs are concerned with effective use of limited natural resources and development of alternate sources of energy. Computers are no longer the way of the future, they are a part of everyday life. Thus computer programming and program design have become increasingly important elements of individual programs. The management of hazardous wastes, bio-medical engineering, and applications of technology assessment are areas of study important to society. These same areas are of increasing interest to students. They offer direction for developing new pre-college programs.

New programs introduced at the advent of the eighties expanded understanding of technology at work. An Energy & Environmental Technology Workshop for teachers attracted 50 teachers from nine New Jersey counties. Research apprenticeships gave five superior students an opportunity to work directly with faculty researchers. The Chemical Industry Minority Engineering Program gave 23 students a working knowledge of chemical engineering at the same time it served as a prototype for future programs at other institutions. An introduction to Urban Engineering for Junior High School Students is the realization of a goal; reaching students when counseling and career information can influence high school curriculum selection.

Most pre-college programs are open to all students who demonstrate a good record of achievement in mathematics and science and who are recommended by their teachers. Others are designed in cooperation with specific high schools. All provide direct benefits to the students. Components include academic enrichment and reinforcement, career counseling, college orientation, and personal enrichment through field trips and exposure to guest speakers from business and industry.

Assuming the availability of funding, the Institute intends to continue its array of programs in response to demand. Ultimately a comprehensive sequential program from post-seventh through twelfth grades will be in place. All programs, current and proposed, are dependent on the presence of resources and personnel that ensure the maintenance of quality.

THE CENTER FOR PRE-COLLEGE PROGRAMS

The Center for Pre-College Programs was established in 1979 to coordinate the [illegible] growing number of relationships with secondary school teachers and [illegible] increasing demands on resources and personnel, a need to develop [illegible], and a desire on the part of the Institute to involve [illegible] secondary school representatives in the activities of the Center all contributed to the decision to adopt the Center format.

An Advisory Board with majority membership from outside the Institute offers leadership and direction to the Center. Board members are concerned with the development of policies and procedures that ensure accountability of [illegible] programs. [illegible] support from the private sector, both financial and through [illegible], is a major function of board members. The Advisory Board [illegible] the NJIT campus.

The Center is affiliated with the Foundation at New Jersey Institute of Technology, a [illegible] non-profit corporation which encourages excellence at [illegible] graduate study and public service programs at [illegible] high school [illegible] to the [illegible] Executive General Manager Business Services of New Jersey Bell [illegible], a Director of the Advisory Board. Dr. Howard [illegible] Director of [illegible] is Director of the Center.

2

A MESSAGE FROM THE CHAIRMAN OF THE ADVISORY BOARD

It is no secret that business and industry must look more to minorities and women to meet the need for professional personnel in the years directly ahead. During a period when the college-age population is about to decline, the demand for services is expected to increase as the consumer population grows. Blacks, Hispanics and women, currently under-represented in high demand fields such as engineering and related technological specialties, must have early encouragement if they are to prepare for careers in fields in which they are welcome and needed. Because pre-college programs are most often directed toward these audiences, the private sector would do well to support such programs.

New Jersey Institute of Technology's progress in stimulating interest in the technological fields through programs for secondary school students is an outstanding example of what can be accomplished. A working partnership with the private sector has enabled NJIT to develop meaningful reinforcement and enrichment offerings that annually reach upwards of 1,000 young men and women. As a technological university located in Newark, NJIT has a concentration of special faculty expertise, contemporary physical resources, and a proximity to urban populations important to successful programming.

The record shows that graduates of NJIT's pre-college programs are better prepared to succeed in high education, particularly in curricula where strong background in mathematics and science is vital. Emphasis at NJIT is on participation rather than observation, an important motivational factor in helping participants make personal decisions among many career options.

NJIT's commitment to pre-college programs is firm. So long as qualified personnel and physical resources are available for the continuation of quality programming, the Institute accepts, as part of its public service mission, the creation and support of the Center for Pre-College Programs. NJIT is the vehicle and not the benefactor, and as such requires commitments from the private sector. Modest investments by the private sector are required to make the programs work.

The Center for Pre-College Programs welcomes inquiries from business and industry, large and small. Participation may take many forms. In addition to direct financial support, opportunities are available to host students on field trips, participate in workshops and career programs, sponsor cultural events, or enhance individual programs in other ways.

New Jersey Institute of Technology and those in the corporate community who support pre-college programs extend an open invitation to you to join us.

Gerald E. O'Loughlin
Chairman
Advisory Committee
Center for Pre-College Programs

A MESSAGE FROM THE PRESIDENT OF NJIT

Many of today's young people are intensely curious about how technology relates to their daily lives. Sustaining and nurturing that interest and channeling it into a perspective in which they see themselves as creative professionals rather than observers of a passing scene, is quite another matter.

New Jersey Institute of Technology has long been at the forefront of the nation's institutions reaching out to these youngsters. An array of on-campus programs promote an understanding of technology. Pre-college students at NJIT deal with a range of problem solving activities. They study the urban complex – the problems of air and water pollution and the overall problem of environmental degradation. They propose approaches for improving traffic patterns, creating parks and playgrounds, and generally improving the quality of urban life.

Although NJIT's Pre-College Programs differ from one another, they do share a number of objectives. Academic reinforcement in mathematics and science is built into each program. Communications skills are emphasized as necessary to all endeavors. And the relationship of technology to the people it serves is stressed. Field trips and workshops expose participants to what often is their first glimpse of the working world of professionals. Career counseling and an introduction to a college atmosphere add to their growth as they prepare to make important personal decisions that will affect their future.

We at New Jersey Institute of Technology are concerned that there is a limited presence of Blacks, Hispanics and women in engineering and other technological professions. Special efforts are made to attract minorities and women to the pre-college programs, efforts that have been highly successful.

By developing skills and stimulating students to test their interest in science, NJIT is helping to meet the growing need for engineers and technologists.

While most of the Institute's programs are directed to students who demonstrate a good record of achievement in mathematics and science, not all participants elect to pursue careers in technological or managerial fields. However, given the impact of technology on society, all gain from the experience whatever the future educational or career direction.

Programs offered through the Center for Pre-College Programs are possible because of an effective partnership. Federal agencies such as the National Science Foundation and the Department of Education encourage and support some programs. Private philanthropic organizations and the corporate sector represent the most important sources of assistance. New Jersey Institute of Technology, for its part, provides physical resources and personnel. Such a partnership is critical to the maintenance of pre-college programming.

As a university, NJIT must meet its primary mission elements of instruction and research, allocating its limited financial resources toward that end.

It is a goal of the Center for Pre-College Programs to develop comprehensive sequential offerings for students from seventh through twelfth grades. The value of such a program to individual students, and to society, encourages all of us to pursue the realization of that goal with vigor.

Saul K Fenster

CENTER FOR PRE-COLLEGE PROGRAMS
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Dept. of Civil & Environmental Engineering

Dr. Howard Kimmel*
Professor
Dept. of Chemical Engineering & Chemistry

*Directors of The Center for Pre-College Programs

PROGRAM DIRECTORS

Upward Bound
Mr. William Freeman, Director

College Bound
Ms. Anne Wright, NJIT
Ms. Janet MacEachen, East Side H.S.
Mrs. Lillian Lago, Central H.S.

University High Integrated Calculus/Physics
Dr. William Savin

Urban Engineering
Dr. Howard Kimmel
Dr. Harold Deutschman

Mini-Courses: Urban Engineering
Dr. Harold Deutschman
Dr. Howard Kimmel

Science High School Laboratory Course
Dr. Howard Kimmel
Prof. Leon Landsman

Energy/Environment for Secondary School Teachers
Dr. Howard Kimmel

Project SEED
Dr. Joseph Bozzelli
Dr. Arthur Greenberg

Chemical Industry Minority Engineering Program (ChIME)
Dr. Reginald P.T. Tomkins

COLLEGE BOUND PROGRAMS NJIT AND CENTRAL HIGH SCHOOL

The College Bound Program is a cooperative program offered during the academic year by New Jersey Institute of Technology and Central High School. Central High School students are provided with academic support, tutoring, counseling and enriching social experiences. [illegible]

DATA

Audience: Youth, Newark

Number of Students Enrolled: Approximately [illegible]

Academic Emphasis: English, Mathematics and Science

Distinctive Characteristics [illegible] Program: College Bound serves as a college preparatory project for the students involved. Tutoring is offered at all grade levels and visits to colleges and career counseling are arranged for students.

Sponsor: The Florence and John Schumann Foundation

Time Frame: Central High's school year.

INTEGRATED CALCULUS-PHYSICS COURSE AT NJIT

This program was created as a special curriculum for Newark's University High School, an honors high school that enrolls high ability, highly motivated secondary school students in Newark. NJIT's specialized course stresses the development of good study habits as part of the overall learning process. College credit based on level of academic performance is available to participants.

DATA

Audience Served: Newark

Number of Students Enrolled: Approximately 15

Academic Emphasis: Mathematics, Science

Distinctive Characteristics of Program: Laboratory sessions and tutoring by NJIT faculty and students provide an opportunity for individualized instruction. Each student receives a scientific calculator for use during the course.

Sponsors: Mobil Research & Development, Burroughs Corporation

Time Frame: Academic year

NJIT/SCIENCE HIGH SCHOOL LABORATORY COURSE

A cooperative enterprise between NJIT and Newark's Science High School, the **Laboratory Course** is held in the chemistry and physics laboratories of the Institute. Laboratory experiments under the supervision of faculty acquaint Science High School students with college-level procedures, instruments, and study areas. The course builds on the experiences of the science orientation of participants.

DATA

Audience Served: Newark

Number of Students Enrolled: Approximately 15

Academic Emphasis: Chemistry, Physics, Engineering related subjects.

Distinctive Characteristics of Program: Each week students perform an experiment utilizing different laboratory equipment and facilities. Experiments are supervised by NJIT faculty members and teaching assistants, as well as by a Science High School teacher.

Sponsors: NJIT, Vincent and Anna Visceglia Foundation

Time Frame: Academic year.

PROJECT SEED, CATALYST PROGRAM

Project SEED (Subcommittee for the Employment and Education of the Disadvantaged) is an assistance program for individuals qualifying as culturally and economically disadvantaged. The program provides a stipend of $500 for each student. Participants are assigned to work with faculty and graduate students as part of chemical research groups and are encouraged to develop research projects of their own.

DATA

Audience Served: Newark, Hillside, Plainfield.

Number of Students Enrolled: 3

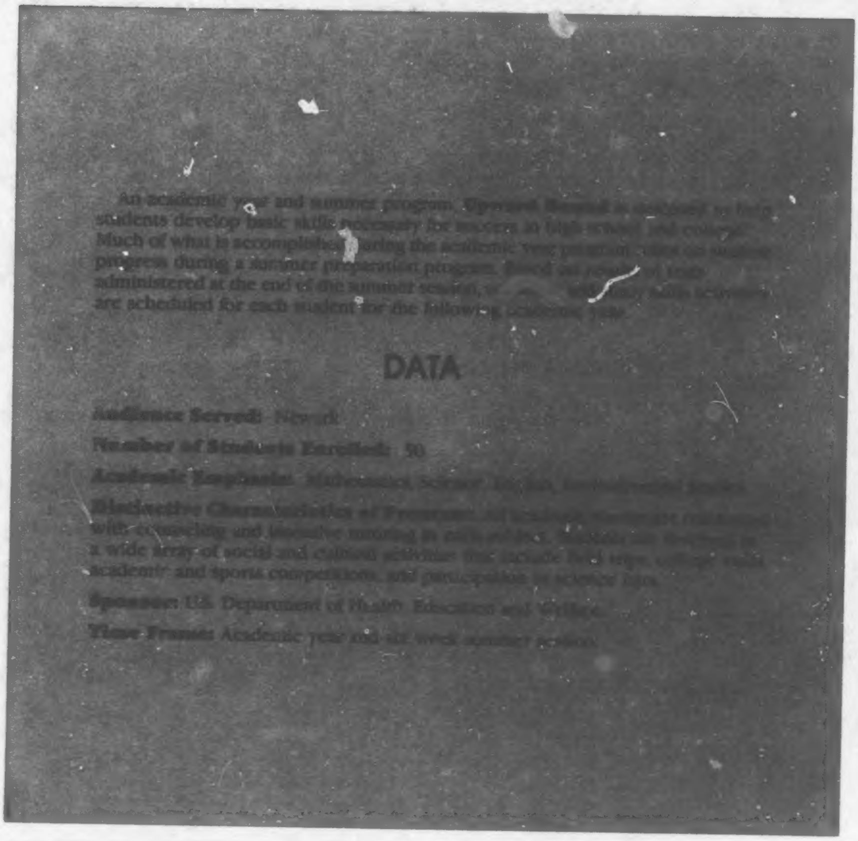
Academic Emphasis: Chemical Engineering and Chemistry

Distinctive Characteristics of Program: Opportunity to work on a one-to-one relationship with a college faculty member on a research project. Increased awareness of science, greater self-confidence.

Sponsors: American Chemical Society and NJIT

Time Frame: 10 weeks over summer.

UPWARD BOUND PROJECT



An academic year and summer program, Upward Bound is designed to help students develop basic skills necessary for success in high school and college. Much of what is accomplished during the academic year program relies on student progress during a summer preparation program. Based on results of tests administered at the end of the summer session, w[illegible] basic activities are scheduled for each student for the following academic year.

DATA

Audience Served: Newark

Number of Students Enrolled: 50

Academic Emphasis: Mathematics, Science, English, Environmental Studies

Distinctive Characteristics of Program: All academic instruction is combined with counseling and intensive tutoring in each subject. Students are involved in a wide array of social and cultural activities that include field trips, college visits, academic and sports competitions, and participation in science fairs.

Sponsor: U.S. Department of Health, Education and Welfare.

Time Frame: Academic year and six week summer session.

JUNIOR HIGH SCHOOL INTRODUCTION TO URBAN ENGINEERING

The objective of **Introduction to Urban Engineering** program is to introduce students to the excitement of science and engineering with insight into the role of engineers and scientists as problem solvers. Emphasis is placed on developing techniques to solve urban problems. Guidance ensures that students are aware of requisite science and mathematics courses necessary to qualify for admission to college.

DATA

Audience Served: Largely Newark and East Orange.

Number of Students Enrolled: 87

Academic Emphasis: Urban Planning, Transportation Engineering, Environmental Science and Energy.

Distinctive Characteristics of Program: The program includes special projects on which the students work as groups. They become urban planners for a group-created community in which they identify and eliminate existing problems related to urban living, transportation systems and the general environment.

Sponsors: National Science Foundation, Exxon Research & Development, Mobil Research & Development, Public Service Electric & Gas Co., Prudential, Bell Labs, New Jersey Bell, Hoffmann-La Roche.

Time Frame: Three week summer session.

HIGH SCHOOL URBAN ENGINEERING

The oldest continuous pre-college program at NJIT, the **High School Urban Engineering** Program uses the engineering approach to urban problem solving. Students deal with problems that affect the quality of life in urban areas and are exposed to relevant topics in the urban engineering field. The program, initiated in 1971, offers high school juniors and sophomores project experience in groups on specific problems.

DATA

Audience Served: Newark, East Orange, Orange

Number of Students Enrolled: 81

Academic Emphasis: Urban Planning and Design, Transportation Planning, Energy Resources and Systems and Computer Science as they relate to the urban engineering subject matter.

Distinctive Characteristics of Program: The program includes projects in which the students work in groups with faculty members on specific urban problems.

Sponsors: United States Department of Energy, National Science Foundation, Exxon Research & Development, Mobil Research & Development, Public Service Electric & Gas Company, Prudential, Bell Labs, New Jersey Bell, Hoffmann-La Roche.

Time Frame: Six-week summer program.

RESEARCH APPRENTICESHIP PROGRAM FOR MINORITY HIGH SCHOOL STUDENTS

This program provides an [illegible] of opportunities for research in Environmental Engineering and Energy Systems. NJIT faculty cooperate with students during the summer to develop individual projects. Students' [illegible] after-school work [illegible] during the academic year by high school students. Through a series of lectures, presentations by speakers, and field trips, the students are made aware of the impact of modern society on the environment and the world's natural energy [illegible]. Remedies to problems, methods of conservation and possible alternate sources of energy are explored.

DATA

Academic Setting: Newark and Plainfield.

Number of Students Enrolled: 5

Academic Emphasis: Civil, Environmental, and Chemical Engineering.

Distinctive Characteristics of Program: Through demonstrations and laboratory exercises the students learn about and become proficient in many of the lab procedures used for chemical and bacteriological examination of water and energy materials.

Sponsor: National Science Foundation.

Time Frame: Summer session and academic year.

SATURDAY MINI-COURSES

Mini-courses extending over two and three week periods are held Saturdays during the academic year for high school juniors and seniors. [illegible] Instruction in computer programming, computer applications and environmental/urban planning are among the offerings.

DATA

Audience Served: Newark and surrounding Municipalities.

Number of Students Enrolled: [illegible].

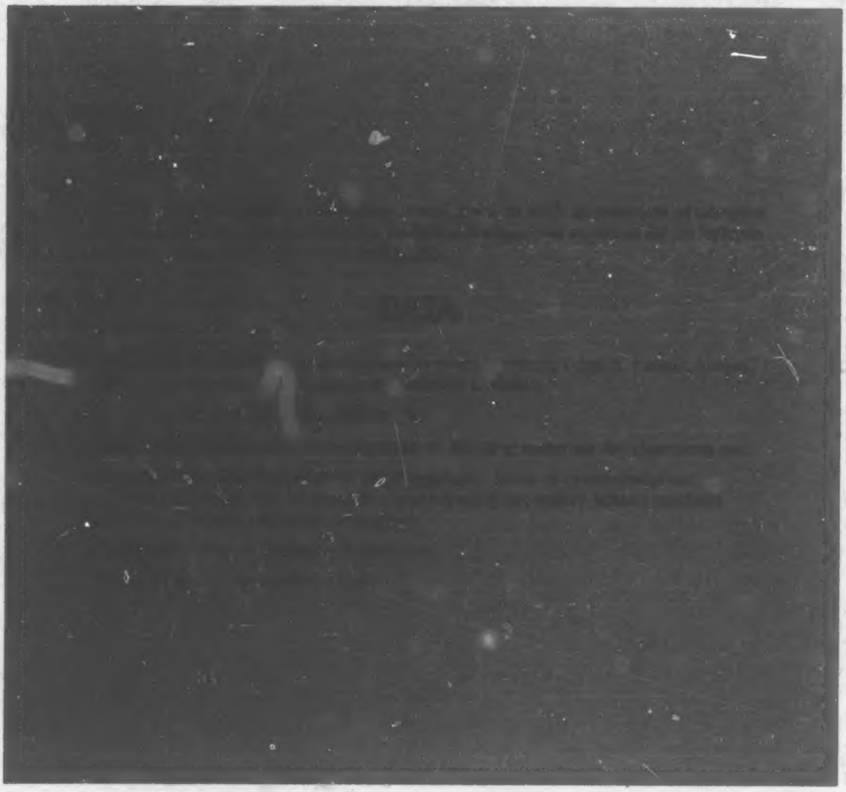
Academic Emphasis: As described above.

Distinctive Characteristics of Program: High percentage of minority students; self-motivation for increased knowledge.

Sponsors: Shelby Cullom Davis Foundation.

Time Frame: Saturdays, academic year.

ENERGY AND ENVIRONMENTAL TECHNOLOGY FOR SECONDARY SCHOOL TEACHERS



DATA

ChiME WORKSHOP FOR HIGH SCHOOL STUDENTS

[illegible]

DATA

[illegible]

ENERGY EDUCATION WORKSHOPS

5

These workshops, held in cooperation with the Irvington and Newark Boards of Education, [illegible] of energy resources.

DATA

Audience Served: Newark and Irvington

Number of Teachers Enrolled: [illegible]

Academic Emphasis: Energy production

Description of Characteristics of Workshop: Teachers are taught on current issues and trends in energy production and are introduced to curriculum materials available for use in classrooms.

Sponsors: NJIT & Newark and Irvington School Districts.

Dates Offered: February, [illegible]

ENERGY CONVOCATION FOR GIFTED ELEMENTARY SCHOOL CHILDREN

[illegible]

1980-81 PRE-COLLEGE PROGRAMS

PROGRAM	AUDIENCE
College Bound	Central H.S. Newark
Integrated Calculus - Physics Course	University H.S. Newark
Science High School Laboratory Course	Science H.S. Newark
Project SEED - Catalyst Program	Newark, Hillside & Plainfield
Upward Bound Project	Newark High Schools
Junior High School Introduction to Urban Engineering	Newark & Regional N.J. & N.Y. Junior High Schools
(Senior) High School Urban Engineering	Newark & Regional N.J. & N.Y. High Schools
Research Apprenticeships, for Minority H.S. Students	Newark, Plainfield

TIME FRAME	SPONSORS
September - June	Florence & John Schumann Foundation
September - June	Mobil Research & Development, Burroughs Corporation
September - June	Visceglia Foundation NJIT
10 weeks Summer Session	American Chemical Society NJIT
September - June Six Week Summer Session	Department of Health, Education & Welfare
Three Week Summer Session	National Science Foundation Exxon, Bell Laboratories; The Prudential Foundation, Mobil R&D, Hoffmann-La Roche
Six Week Summer Session	National Science Foundation Exxon, The Prudential Foundation, Mobil R&D Public Service Electric & Gas Co., Hoffmann-La Roche
Calendar Year	National Science Foundation

1980-81 PRE-COLLEGE PROGRAMS

PROGRAM	**AUDIENCE**
Saturday Mini-Courses	Newark & Regional N.J. & N.Y. High Schools
Energy & Environmental Technology for Secondary School Teachers	Essex, Hudson, Bergen, Union, Morris, Monmouth, Middlesex, Passaic & Somerset County School Districts
WORKSHOPS	
Chemical Industry Minority Engineering Program Workshop for High School Students	Newark, Bayonne, Old Bridge, Plainfield, Elizabeth, Linden, Upper Montclair, South Amboy, Orange
Energy Education	Newark Irvington
Energy Convocation for Gifted Elementary School Students	Hudson County School Districts

TIME FRAME	SPONSORS
12 Saturdays During Academic Year	Shelby Cullom Davis Foundation
September - May	National Science Foundation
Four to five weeks, summer	Chemical Industry Council
February - May	NJIT & Newark and Irvington School Districts
March	Hudson County Schools

PRE-COLLEGE PROGRAMS
AVERAGE PARTICIPATION STATISTICS

NAME OF PROGRAM		ENROLLED
College Bound Program		51
Integrated Physics-Calculus Course		22
Science High School Laboratory Course		14
Project SEED. Catalyst Program		3
Upward Bound Project		50
Junior H.S. Introduction to Urban Engineering		87
High School Urban Engineering		81
Research Apprenticeship for Minority H.S. Students		5
Saturday Mini-Courses		400
Energy & Environmental Technology for Secondary School Teachers		50
	Total	763

NAME OF WORKSHOP		ENROLLED
ChIME Workshop for H.S. Students		23
Energy Education		145
Energy Convocation for Gifted Elementary School Children		60
	Total	228

CONTINUING EDUCATION COURSES

16 Options – one-day programs on variety of topics		150
	Total	150

GRAND TOTAL 1141

ACKNOWLEDGEMENTS

The Center for Pre-College Programs gratefully acknowledges the assistance of sponsors and those friends of New Jersey Institute of Technology whose cooperation has contributed to the success of recent programs.

PROGRAM SPONSORS

American Chemical Society
Bell Laboratories
Burroughs Corporation
Chemical Industry Council
Exxon Research & Engineering Company
The Florence & John Schumann Foundation
Hoffmann-La Roche, Inc.
Mobil Research & Development Corp.
New Jersey Bell Telephone Company
The Prudential Foundation
Public Service Electric & Gas Company
Shelby Cullom Davis Foundation
Victoria Foundation, Inc.
Vincent and Anna Visceglia Foundation

FIELD TRIPS/VISITS

ARRADCOM, Dover, N.J.
Bell Laboratories, Murray Hill, N.J.
Consolidated Edison, New York City
Exxon, Linden, N.J.
Fairleigh Dickinson University
Hoffmann-La Roche, Nutley, N.J.
N.J. Turnpike Authority, East Brunswick
New York University
Procter & Gamble, Staten Island, N.Y.
Stevens Institute of Technology
Trenton State College
Western Electric, Springfield, N.J.

CAREER GUIDANCE SEMINARS

Bendix Corporation
Burroughs Corporation
Ethicon, Inc.
Exxon Research and Engineering
The Grad Partnership
New Jersey Bell Telephone Company
The Prudential Insurance Co. of America
Public Service Electric & Gas Company
Tri State Regional Planning Commission

Dr. **Fenster**. The initial funding for our efforts stimulated an investment by private industry two and a half times the initial support. Having worked with the private sector to build this program I know public private support was crucial, a crucial catalyst in attracting industrial support. Corporate officers have told me time and time again that they view their role as being one part of a triad, a university, government, corporate triad. They don't view their role as replacing lost Federal funds, but they are very happy to work with us in that triad and have been most supportive.

This precollege program, of which I spoke, this year has enrolled 1,000 students, 1,000 students with an annual institutional budget of under $400,000 to support that. We have a very, very high college going rate among students in this program who are largely from minority groups.

These are inner-city youngsters with very, very low family incomes. There simply is no easy way of telling to what extent we may have turned what could have become in some instances potentially antisocial behavior which often flows from poverty and disadvantagement to productive earning role in society contributing to the national economy, contributing to the national defense.

Now in 1982 the dual mission of the Foundation of which we spoke is being abrogated with the Reagan administration's proposals to significantly reduce all education programs. The higher education community, collectively and individually, testified last year before various congressional committees urging the rejection of the administration's plan as a shortsighted and strategic error. We believe that the reasons for the Foundation's charter in science and engineering education remain as valid today as they did in 1950 and that adequate funding for science and engineering education must continue.

I urge this subcommittee to once again reject the administration's fiscal year 1983 plan and provide additional funding for a range of educational activities at the Foundation. These activities should include funds for instructional equipment, course development and personnel improvement. With respect to the Foundation's proposal to establish a Special Commission on Science and Engineering Education, I share with the members of this committee a concern that the Commission is viewed as a substitute for action that is desperately needed.

I would like to comment now on the reduction of science and engineering education funding and its effect. What will be the likely long-term effect on our Nation if the science and engineering education programs of the National Science Foundation are eliminated?

First, the size of the pool from which future scientists and engineers will be drawn will be severely reduced. By 1995 the proportion of the total population in the 18–24 age range will be 25 percent less than it was in 1980, a very crucial demographic fact of life about which we can do very little.

People have already been born. They are already entering the high school stream and graduating.

If, as we approach the end of this century, the number of scientists and engineers is not to decrease in absolute terms—let alone increase to meet what by then will be an increasing industrial and military demand—the proportion of this population prepared for higher education in science and engineering must increase. The only way the numbers can be kept constant is by increasing the fraction of the high school population that participates because the number of high school graduates is going to drop inevitably.

But if the Federal science career motivation programs are cut off, we can expect a smaller proportion, and hence a smaller number of young children to be attracted to science and engineering careers.

Second, new entrants into the Nation's technical and managerial work force will, in the aggregate, be increasingly underprepared to function effectively. Even now the schools are failing to turn out graduates who can cope with the increasingly technical nature of work in commerce, industry, and the military.

To allow the situation to become still worse by withdrawing the only Federal effort that addresses the educational roots of our productivity/security concerns, is to incur enormous national, if not Federal, costs. Each year that the system fails, the "educational national debt" grows, ultimately to be paid by the public. Industry and the military must provide science and mathematics education to make up for school failures.

To the extent that our business and defense establishments are unable to rectify previous science education failures, productivity lags further, inflation worsens, public costs soar. The effect is cumulative.

Each year that we let this problem go unattended by national leadership and resources, we mortgage the economy, and face the unhappy, totally unnecessary prospect in a few years of either investing in expensive reeducation or paying the price of ill-prepared workers year after year.

If the Federal role in education is now diminished virtually eliminating NSF involvement, then there is little chance of turning things around. The price we will pay—in terms of scientific career development and a technically competent work force will be out of proportion to the money saved by orders of magnitude.

The present crisis presents the best opportunity that has existed in several years to refocus and sharpen the NSF effort. However, it would be unwise, and inefficient, to phase out all NSF science and engineering education activities while this reconceptualization is taking place as has been suggested by at least one or two of the earlier speakers.

What do we do in the meanwhile? Momentum would be lost. Valuable programs interrupted. By the way, we have a good inventory, a good sense of what are the successful programs. We need to do a little post audit on them and determine which have worked through college going rates, through people who eventually end up in science and technical careers who come from a variety of backgrounds.

We can assess this without a protracted study and without the waste of science and engineering that might be attendant thereto.

We cannot have our attention diverted to the logistics of phasing out the budget, facilities, and personnel of a doomed enterprise.

I am particularly disturbed at the Foundation's announced plans to eliminate the science education directorate and establish a Bureau of Science Education.

To comment on H.R. 5254, I would like to take this opportunity to express my support for H.R. 5254, the National Engineering and Science Manpower Act. I applaud the committee's initiative in formulating this legislation.

H.R. 5254, by providing for a national policy for engineering, technical, and scientific manpower, and by creating a National Commission for Engineering and Scientific Manpower, focuses attention on the severity of the problem at hand and proposes alternative solutions that are not simply requests for more money.

As a president of an institution with strong technical and engineering programs, I can comment first hand on the problems encountered by engineering schools today. Other members of our Association note similar experiences.

Undergraduate engineering enrollments are rapidly increasing. Yet this tremendous increase in size has not been reflected in equal growth of faculty, resources or equipment. On the contrary, most institutions have had to deal with more students and less faculty.

Some examples. At the present B.S. graduates from engineering schools are getting annual salaries upon graduation which exceed academic salaries of new faculty with doctorate degrees. Every graduate of New Jersey Institute of Technology received at least three job offers. This year 350 companies have come to campus to recruit over 600 or 650 graduates. Thus, at my institution we were able to fill but one-third of the available faculty openings.

Some of our classes are larger than desirable. This is particularly serious in our design courses where individual and small group attention is vital, where many solutions to design problems are possible and all have to be checked intensely and individually by our faculty.

The New Jersey Institute of Technology requires a minimum of $2 million to upgrade equipment. Our plan is to spend $400,000 a year for over 5 years. We are currently falling behind by about $200,000 a year and as a result, we have not been able to replace the equipment we sorely need.

I would add that our institution and many other institutions in the public and private sectors are not simply sitting idly by watching the phenomena of equipment becoming obsolete and facilities becoming obsolete and so on. All sorts of creative approaches are being tried. Many are being done, by the way, in very close cooperation with the corporate community which sees this crisis in science and technological education as strategic to them as well.

What we must continue to do is reenforce that partnership of the universities and colleges, the corporate community, and the Federal and State governments. We dare not let the Federal Government lag in its efforts in this partnership.

Mr. Chairman, I thank you for this opportunity to be before this committee today. Of course, I would be pleased to respond to any questions.

[The prepared statement of Mr. Fenster follows:]

PREPARED STATEMENT BY SAUL K. FENSTER, PRESIDENT, NEW JERSEY INSTITUTE OF TECHNOLOGY

My name is Saul Fenster and I am President of New Jersey Institute of Technology in Newark, New Jersey, a position I have held for the last four years. Prior to assuming the Presidency of New Jersey Institute of Technology I was Chairman of the Department of Mechanical Engineering, Associate Dean of Engineering and Provost at Farleigh Dickinson University. I received a BME from City University of New York, an MS from Columbia University, and a Ph.D. from the University of Michigan. I am a member of the American Association for the Advancement of Science, American Society for Mechanical Engineering and American Society for Engineering Education.

I am pleased to have the opportunity to appear before this Subcommittee today to testify on the fiscal year 1983 National Science Foundation Authorization Bill, with particular emphasis on the Science and Engineering Education Directorate.

I represent the 353 member institutions of the American Association of State Colleges and Universities and am currently Vice Chairman of its Committee on Science and Technology. I am also speaking on behalf of the following associations: American Council on Education; American Educational Research Association; Associated Colleges of the Midwest; Association of Affiliated College and University Offices; Association of American Colleges; California State University; Council of Graduate Schools in the United States; Council of Independent Colleges; National Association of State Universities and Land-Grant Colleges; National Association of Schools and Colleges of the United Methodist Church; National Council of Teachers of Mathematics; and State University of New York.

Our institutions are located throughout the United States, and include seventeen colleges in Pennsylvania, nineteen colleges in California, eight colleges in Ohio, eighteen colleges in New York, twenty-five colleges in Texas, nine colleges in Oklahoma, eleven colleges in Massachusetts, six colleges Minnesota, two colleges in New Hampshire, three colleges in New Mexico, nine colleges in New Jersey, seven colleges in Florida, and five colleges in Kansas.

With a combined enrollment of over 2½ million students, the 353 state colleges and universities of AASCU enroll one out of four of all baccaluaretate degree students in the country. Our institutions play a major role in our nation's science effort. Many students who ultimately pursue advanced degrees in scientific and technical fields receive their basic undergraduate training at our institutions. A large portion of the nation's future elementary and secondary school science and mathematics teachers are educated at AASCU colleges and universities. These teachers must be able to communicate the knowledge and skills that will enable our youth to live in an increasingly complex and technology-dependent society. AASCU institutions award close to 30 percent of the B.S. degrees in engineering annually.

Mr. Chairman, it gives me great pleasure to appear before you today in the company of the other distinguished witnesses. In the past, this Subcommittee has been a strong supporter of our nation's efforts to adequately fund science and engineering education. Your recommendations on the fiscal year 1982 NSF authorization bill rejected the Administration's proposal to terminate science and engineering education and suggested guidelines for funding that acknowledged the necessity for fiscal contraints. I urge you to adopt a similar approach for fiscal year 1983.

The past year has been an increasingly bleak and fustrating one for those of us interested in, and concerned with, the future scientific and technological strength of the United States. The Administration's decision to cut funding for all science and engineering education programs, with the exception of the graduate fellowships program, is an example of fiscal considerations—reduced budgets—interfering with perceived national goals—adequate supply of scientific and technological manpower.

Recently Senator Alan Cranston of California reported in his newsletter on the growing skills gap in human capital. He had asked a leading Califorinia industrialist what single factor was likely to limit his company's capacity to expand and grow. "His answer was surprising. He did not mention capital, or taxes, or even energy. The critical factor, he said, is people—well educated, technically-trained people . . . The new growth industries—computers, robotics . . . are creating highly sophisticated jobs demanding well-trained workers. We can anticipated shortages . . . We face a serious skilled labor crisis in the 1980's . . . I fault the . . . Administration for ignoring this coming crisis, for its pound-foolish cutbacks in science education and science promotion . . . We must tend to the state of our skilled labor force . . . our human capital. This will require a major investment in education and job training."

THE CHANGING INTERNATIONAL ENVIRONMENT: THREATS TO U.S. TECHNOLOGY

The proposed cutback in funding for science and engineering education comes at the very time on our history when the U.S.'s position of world leadership in science and technology is being severely challenged. The proposed cuts, we believe, ultimately will jeopardize our national security and economic well-being by undermining American industrial, commercial, and military strengths. D. Allan Bromely, Retiring President of the American Association for the Advancement of Science, recently noted that "to expect scientific and technological progress while abandoning efforts at improving science and technological teaching in our schools is illogical and a disservice to the nation's interests."

The severity of the situation was highlighted in a recent study by SRI International that compared the education and employment of scientists and engineers in the U.S. and the USSR. Based on its findings the report concludes that "there is a need for concern in the U.S. and that concern shoud be manifested in a systematic and comprehensive review of our training of Americans at all levels of education for an increasingly scientific and technological world. Such a review will undoubtedly indicate that changes are required, and we should be prepared to make them . . . If anything less is accepted as a national objective, then there is cause for alarm."

I would like to cite some examples that cause me to be alarmed about our nation's future scientific and technological base.

Manpower shortages in engineering and computer specialists are contributing to the decline in productivity and the decline in U.S. share of world trade. Between 1963 and 1977 productivity increased in the manufacturing industries of the United Kingdom by 51 percent, of West Germany by 114 percent, of Japan by 197 percent, and of the United States by 39 percent. During that same time the U.S. share of world trade in manufactured items declined from 21 percent to 16 percent, while Japan's share increased from 8 percent to 15 percent.

Only one-third of the nation's 17,000 school districts require graduates to take more than one year of math or science, and seven states require no high school mathematics.

The Department of Defense reports that it has problems recruiting and retaining civilian and military engineers; the Air Force reports a shortage of 1,100 engineers in ranks. It also notes that it is more and more difficult to find officers and NCO's who are qualified to be trained to operate increasingly sophisticated military hardware.

In Japan the number of degrees granted to engineers in recent years has surpassed the number granted in those same years in the U.S., though Japan's population is one-half of ours. The Soviet Union graduates more than twice as many scientists and engineers as does the U.S., and has almost five times as many engineering students. The U.S. ranks third behind the Soviet Union and Japan—in the proportion of engineering graduates in the population.

Against this ominous background, our nation's science and engineering education establishment is beset by a range of problems. This subcommittee is all too familiar with the litany—shortages of math and science teachers in elementary and secondary schools, inadequate laboratory facilities in colleges, lack of research experiences for undergraduate students, rising undergraduate engineering enrollments coupled with shortages of engineering faculty and obsolete equipment. You, as well as I, know that our system of science and engineering education is in a state of crisis. What we lack however, is a nationwide commitment and agenda to deal with these problems.

THE ROLE OF THE NATIONAL SCIENCE FOUNDATION

I strongly believe that the National Science Foundation must play a leading role in restoring the health of American science education.

When the National Science Foundation was established in 1950, it was authorized and directed to "initiate and support basic scientific research and programs . . . and science education programs at all levels." The educational mandate of the National Science Foundation has been an integral part of our nation's scientific establishment since that time. It was clearly reaffirmed when Congress in 1979 rejected proposals to move the science education programs out of the National Science Foundation to the newly created Department of Education.

The NSF's support of science and engineering education has been crucial to my institution. Currently NJIT has a large and successful Center for Pre-College Programs. The aim of these programs is to provide disadvantaged students—many of them from minority groups—with the technical skills necessary to pursue careers in sciences or engineering. It is a demanding program, but 92 percent of our participants successfully completed it and go on to college.

The NSF originally funded support for this program and it served 245 students. With this in operation, we were able to go to the corporate and industry community for additional support. Now the programs serve 1,000 students. The government seed money stimulated an investment by private industry that was 2½ times the original federal support. Having worked with the private sector to build this program, I know that the federal support was the crucial catalyst in building industrial support.

Now in 1982, this dual mission of the Foundation is being abrogated with the Reagan Administration's proposals to significantly reduce all education programs. The higher education community, collectively and individually, testified last year before various Congressional committees urging the rejection of the Administration's plan as a shortsighted and strategic error. We believe that the reasons for the Foundation's charter in science and engineering education remain as valid today as they did in 1950 and that adequate funding for science and engineering education must continue.

We were somewhat encouraged last year by Congressional decisions that restored a limited amount of funds for the National Science Foundation to conduct the education programs that are mandated in its charter. The need for science and engineering education programs is great, yet the monetary resources available this year (a little over $20 million) will be disproportionate to that need. I urge Congress to once again reject the Administration's fiscal year 1983 plan to eliminate all science and education programs, except fellowships, and to provide funding for a range of education activities at the Foundation.

What role should the National Science Foundation play in correcting the disparity between available resources and perceived needs? One approach would be for a clear and unequivocal call for increased funding of science and engineering education programs. Such a call coming from an eminent group of scientists would serve to dramatize the problems at hand and the range of solutions necessary to deal with them.

In contrast, however, the Foundation has proposed the establishment of a Special Commission of Science and Engineering Education. This Commission will assess the quality of science education in the secondary schools. It will define and articulate an agenda which would encourage state and local government and private organizations to address these issues.

We are concerned that the Commission will not place adequate emphases on the problems of science education at the collegiate level. For the record, I would like to introduce a letter written by Allan W. Ostar to the NSF expressing our concern.

THE REDUCTION OF SCIENCE AND ENGINEERING EDUCATION FUNDING: ITS EFFECT

What will be the likely long-term effect on our nation if the science and engineering programs of the National Science Foundation are eliminated?

First, the size of the pool from which future scientists and engineers will be drawn will be severely reduced. By 1995 the proportion of the total population in the 18–24 age range will be 25 percent less that it was in 1980. If, as we approach the end of this century, the number of scientists and engineers is not to decrease in absolute terms—let alone increase to meet what by then will be an increasing industrial and military demand—the proportion of this population prepared for higher education in science and engineering must increase. But if federal science career motivation programs are cut off, we can expect a smaller proportion, and hence a smaller number of young children to be attracted to science and engineering careeers.

Many of those children who do become interested in science when very young will be turned away by the poor quality of science teaching they encounter in their junior and senior high schools. Without federal help science and mathematics teaching will be unable to keep current with new developments. Without federally funded in-service institutes high school science and mathematics teachers will fall further behind in their subjects, and their already damaging isolation from ongoing contact with research and the real world of science will be made more complete. Without federal assistance colleges and universities will be unable to upgrade instructional laboratory equipment, introduce important new scientific and educational concepts to undergraduates and, in general, improve the quality and effectiveness of undergraduate science education. Every year this persists will be a year that hastens the increasing shortfall of scientific human resources.

Second, new entrants into the nation's technical and managerial work force will, in the aggregate, be increasingly underprepared to function effectively. Even now the schools are failing to turn out graduates who can cope with the increasingly technical nature of work in commerce, industry, and the military. To allow the situation to become still worse by withdrawing the only federal effort that addresses the educational roots of our productivity/security concerns, is to incur enormous national (if not federal) costs. Each year that the system fails, the "educational national debt" grows, ultimately to be paid by the public. Industry and the military must provide science and mathematics education to make up for school failures. To the extent that our business and defense establishments are unable to rectify previous science education failures, productivity lags further, inflation worsens, public costs soar. The effect is cumulative. Each year that we let this problem go unattended by national leadership and resources, we mortgage the economy, and face the unhappy, totally unnecessary prospect in a few years of either investing in expensive "re-education" or paying the price of ill-prepared workers year after year.

If the federal role in education is now diminished virtually eliminating NSF involvement, then there is little chance of turning things around. The price we will pay—in terms of scientific career develoment and a technically competent workforce will be out of proportion to the money saved.

The present crisis presents the best opportunity that has existed in several years to refocus and sharpen the NSF effort. However, it would be unwise, and inefficient, to phase out all NSF science and engineering activities while this reconceptualization is taking place. Momentum would be lost, valuable programs interrupted, talent dispersed, and attention diverted to the logistics of phasing out the budget, facilities and personnel of a doomed enterprise. In this regard, reduction in personnel at the Science and Engineering Education Directorate is particularly serious.

Science education at NSF must be restructured so that it can be restored as a more effective partner in sharing with state and local agencies and public and private institutions the responsibility for, and costs of, putting science education back on its feet in this country and keeping it there. In order to achieve such a revitalization it will be important for certain problems to be dealt with thoughtfully and imaginatively by the NSF, the National Science Board, OMB, and Congress.

Recently, AASCU surveyed its membership to learn how science and engineering education cuts would affect course offerings in these areas. I include for your information in the attached appendix a summary of these comments. Without an exception, the institutions agreed that it would be difficult and probably impossible, to continue to offer those science and engineering education courses that had been previously supported by NSF.

H.R. 5254, NATIONAL ENGINEERING AND SCIENCE MANPOWER ACT

I would like to take this opportunity to express my support for H.R. 5254, the National Engineering and Science Manpower Act. I applaud the committee's initiative in formulating this legislation.

The hearings that preceded the introduction of this legislation defined the problem now facing our nation in engineering and technical manpower. All the evidence introduced at that time agreed that there was, and will continue to be, a shortage of engineers. The committee heard testimony from academic, military, and corporate representatives that spoke of the need for a broad and comprehensive policy, as well as a national commitment, to begin addressing these problems.

H.R. 5254, by providing for a national policy for engineering, technical, and scientific manpower, and by creating a National Commission for Engineering and Scientific Manpower, focuses attention on the severity of the problem at hand and proposes alternative solutions that are not simply requests for more money.

As a president of an institution with strong technical and engineering programs, I can comment first hand on the problems encountered by engineering schools today. Other members of our Association note similar experiences.

Undergraduate engineering enrollments are rapidly increasing. Yet this tremendous increase in size has not been reflected in equal growth of faculty, resources or equipment. On the contrary most institutions have had to deal with more students and less faculty.

The hiring of additional Ph.D. faculty for our engineering schools to cope with these enrollment increases has been difficult for two reasons; the faculty salaries are not competitive and the available pool of potential faculty is too small. At the present, B.S. graduates from engineering schools are getting annual salaries upon graduation which exceed academic salaries of new faculty with doctorate degrees. Every graduate of New Jersey Institute of Technology received at least three job offers. This year 350 companies have come to campus to recruit over 600 graduates. Qualified students are thus discouraged from pursuing graduate studies which eventually would lead to a faculty position. When faculty retires we face difficulties in replacing them. Nor are we able to retain the faculty that we have. Each year some are lured away by the higher salaries offered by industry.

The University of Alabama in Huntsville for the past several years has only been able to fill half the engineering faculty positions open; last year, they were only able to fill one position. In addition, the university lost to industry six faculty members. At my institution we were able to fill only one-third of the available faculty openings.

The difficulty of acquiring and maintaining adequate faculty size coupled with rising enrollments has meant that some of our classes are larger than desirable. This is particularly serious in our design courses where individual and small group attention is a must—where many solutions to design problems are possible and all have to be checked individually.

California Polytechnic State University at San Luis Obispo has found class size to be a leading contender in the decline of faculty morale and a contributor to faculty looking for employment opportunities elsewhere. Class size is excessive at all levels, due primarily to budgetary problems and lack of faculty. In the engineering programs there is a serious shortage in faculty which has resulted in the inability of the university to offer certain necessary courses at times when they are required. The possibility of some students making normal progress in their degree program is thus being jeopardized.

Problems caused by faculty shortages and retention are further compounded by the fact that our laboratories do not reflect a state that we regard as adequate. New Jersey Institute of Technology needs a minimum of two million dollars to upgrade equipment. Our plan is to spend $400,000 a year over five years. We are currently falling behind by $200,000 a year and as a result we have not been able to replace the equipment that we need.

Because funding by the State of California has been cut back in the past few years California Polytechnic State University at San Luis Obispo has also been unable to keep abreast of needs in laboratory equipment, maintenance and replacement. They lack technicians to maintain and repair equipment; there isn't enough funds to purchase repair parts and much of the equipment is so old it is difficult to obtain replacement parts. In some cases the University has asked for, and received, donations from industry. Industry's obsolete equipment is then used in the laboratory instruction programs—though obsolete by industry standards this equipment is in most cases newer than the equipment already in the laboratories.

I thank you for the opportunity to appear before this Committee today and would be happy to answer any questions you might have.

American Association of State Colleges and Universities,
Washington, D.C., January 15, 1982.

Mr. John B. Talmadge,
Chairman, Ad Hoc Planning Group, NSB Special Commission on Science and Engineering Education, National Science Foundation, Washington, D.C.

Dear Mr. Talmadge: The American Association of State Colleges and Universities appreciates the opportunity to respond to the National Science Board's proposed plan to establish a Special Commission on Science and Engineering Education.

The past year has been an increasingly bleak and frustrating one for those of us interested in, and concerned with, the future scientific and technological strength of the United States. The Administration's decision to cut funding for all science and engineering education programs, with the exception of the graduate fellowships program, is an example of fiscal considerations—reduced budgets—interfering with perceived national goals—adequate supply for scientific manpower. We were somewhat encouraged by Congressional decisions that restored some limited amount of funds for the National Science Foundation to conduct the education programs that are mandated in its charter. The need for science and engineering education programs is great, yet the monetary resources available this year will be disproportionate to that need.

What role should the National Science Foundation and the National Science Board play in correcting this disparity between available resources and perceived needs? One approach would be for a clear and unequivocal call for increased funding for science and engineering education programs. Such a call coming from an eminent group of scientists and national leaders would serve to dramatize the problems at hand and the range of solutions necessary to deal with them. In contrast, however, the Foundation and the Board have selected an approach that will result in little concrete improvements in our scientific education system.

There are two reasons why the proposed Commission will fail to adequately address what is rapidly becoming a critical situation.

First, the proposed scope of activities and focus of the Commission does not recognize that our educational system is a system. To isolate and examine secondary school education without paying equal attention to primary and higher education ignores the fact that all parts of the American educational complex are interrelated.

The situation in our secondary schools is, indeed critical, but it cannot fruitfully be examined without considering the problems that precede the secondary school. Students at the elementary school level must be adequately prepared in mathematical skills and thinking, and sufficiently motivated and inspired in the sciences. If not, they will arrive in the secondary schools without the proper foundations or interests to pursue more advanced scientific and mathematical courses. In that sense, a Commission which concentrates its efforts on the secondary schools is entering the process six or seven years too late.

By focusing on the secondary schools the proposed plan also ignores the relation that higher education bears to the other educational components. With the removal of federal assistance to colleges and universities, secondary school graduates will find themselves entering higher education institutions with inadequate laboratories and out-of-date curriculum. Higher education's role in training elementary and secondary school teachers, initially and later through in-service and summer institutes, has been an important one. The Commission's approach fails to recognize this training relationship.

One problem in the teacher training system—the problem of attracting and retaining teachers when industrial opportunities and salaries are more attractive—seriously threatens to erode the quality of elementary and secondary school science teachers. The proposed Commission model will be able to do little more than note these trends.

Second, the proposed Commission plans to solve a national problem by local efforts and with local resources. The Statement on NSF Activities in Science and Engineering Education as adopted by the NSB at its 228th Meeting on August 20-21, 1981, states that, "The U.S. requires an educational system equal to its needs and opportunities in science and technology. The NBS is gravely concerned that the Nation is far less well prepared to meet the needs and challenges of the future than is necessary . . ." Throughout this and other supporting documents it is clearly recognized that our scientific educational system and its deficiencies are national problems.

In the Rationale for the Commission it is stated that "in most countries this concern of maintaining science and technology has led to a vigorous effort to upgrade and focus education programs." One only has to look at the systems, and the successes, of two of our industrial competitors in the world market—Japan and West Germany—to understand how the infusion of monetary support and national attention has resulted in a scientific educational system far superior to ours. The Rationale continues by stating that the diversity of our educational system complicates such as approach since problems must be "solved primarily at the level of the local school system."

The message conveyed by this approach is that national leaders will examine national problems, make recommendations, and coordinate activities . . . all this to be done with local dollars. How the local school districts will provide these dollars is unclear. These localities are experiencing severe fiscal constraints which will hamper their efforts.

In your letter of December 29, 1981, you observed that the "Commission's actions have the potential for having more impact than its final report." We agree with that observation and hope that the Commission will act in accordance with our recommendations.

The Association, its staff and member institutions, pledge their cooperation in helping you to formulate an action plan that will begin to solve the inadequacies in Science and Engineering education.

Without such action our nation's economic strength, technological base, and military security will ultimately be threatened.

Sincerely,

Allan W. Ostar, *President.*

AMERICAN ASSOCIATION OF STATE COLLEGES AND UNIVERSITIES INSTITUTIONAL COMMENT ON THE IMPACT OF SCIENCE EDUCATION

NORTH CAROLINA CENTRAL UNIVERSITY

Under an earlier LOCI grant, they developed a set of computer-assisted homework exercises for Introductory Sociology. The concept was to give sociology students laboratory experience in a similar manner to students in the biological and physical sciences where the laboratory begins in the introductory course. The lessons, called Programs from Introductory Sociology (PROFITS), were referred and accepted for distribution by CONDUIT, and are in use at over 100 institutions of higher education in the United States.

At NCCU under a second LOCI grant, they developed computer-assisted homework lessons for teaching sociological statistics. These nine lessons, having been student-tested for three years, are now ready for review and testing by CONDUIT, which has asked to review them. The lessons, called CASE (Computer-Assisted Sociological Exercises), have been used to aid 50 black students at NCCU over a three-year period. Again, national distribution is expected.

STATE UNIVERSITY COLLEGE AT BUFFALO

In a concentrated, six-week summer program 24 high-ability Western New York high school juniors learned how to develop an environmental impact statement and then prepared such a study of a Buffalo area site.

Called by the Buffalo Evening News environmental news editor "one of the best and most complete assessments of Times Beach," the extensive student report would have cost the city at least $50,000 had a professional firm prepared it. Total cost of the educational project was the $17,550 NSF grant, which paid three Colleges at Buffalo faculty, provided supplies and honoraria for 11 special speakers, and supplied a $2 per day commuter allowance for the high school participants. Other costs, such as those for college computer services, were absorbed by the college.

For three weeks the students studied two local case histories—the Love Canal leaking of industrial toxic waste and the West Valley nuclear fuel reprocessing plant—and leanred ecologogical principles and methodologies. The final three weeks were spent in the on-site study of Times Beach. Oral and written presentations of their findings and recommendations were made by the students to a panel of city officials, educators, and ecological specialists.

For at least 16 years National Science Foundation teacher-training programs have been conducted at the college, and 18 programs have been directed by a professor of chemistry, who most recently supervised a four-week, summer 1981 workshop on "Physical Chemistry for Secondary School Teachers of the Biological Sciences."

Revolutionary advances in biological knowledge having come largely from chemists exploring complex structures at both the cellular and sub-cellular levels of organization, it has become essential for biology teachers to be thoroughly familiar with the principles of physical chemistry. Accordingly this course, taught to 30 Western New York teachers in grades 9–12 by three faculty with expertise in molecular biochemistry, physical chemistry, and biological principles, was proposed and received a $13,404 NSF grant. The college provided all classroom space and laboratory equipment.

The summer program was reinforced throughout the following academic year by faculty visits to the teachers' schools as often as requested.

The value of providing science teachers with such opportunities to increase and update their knowledge is evident considering that the current New York State Biology Syllabus contains topics in molecular biology that require a deeper understanding of chemical principles than ever before, yet few NYS biology teacher-training programs require a course in physical chemistry.

Recognizing the increasing need for computer literacy, the College at Buffalo has embarked on a two-year project to develop five instructional modules whose focus is an interactive computer simulation of an environmental issue.

The module subject areas are population, energy, air and water pollution, toxic and hazardous waste, endangered species, and land use for undergraduate environmental science courses.

In the grant proposal that received a NSF $26,720 award and that also has State University of New York support amounting to $13,134, the college pointed out that students taking computer-enriched courses will benefit in several ways. Using the computer to simulate complex systems will increase insight into the nature of such systems and will afford the non-science major an increasingly wanted opportunity for firsthand experience with a computer.

UNIVERSITY OF NORTHERN IOWA

A possible casualty if the cuts are made is a one-of-a-kind program in Iowa that has reached almost 600 elementary and secondary school teachers throughout the state. The Pre-College Teacher Development Program is unique in that it offers a wide selection of short courses to give math and science teachers a look at new development in science and refresher courses in basic science.

UNI faculty members go to outlying areas to teach the courses which include such topics as the body and drugs, energy concepts, microcomputers and hand-held calculators.

TENNESSEE TECH UNIVERSITY

In the fall of 1981, for example, Tennessee Tech's electrical engineering department received a $30,000 Local Course Improvement grant to purchase component parts to build portable digital lab stations for use in student experiments, expanding the curriculum in digital systems design. The university provided an additional $23,000 plus release time for two faculty members to work on the project and design course material for use with the stations. About 150 students will benefit from the program each year.

A $144,000 NSF Comprehensive Assistance to Undergraduate Science Education (CAUSE) grant received in fiscal 1980 was used in the development of an undergraduate interdisciplinary real-time digital system program. The university added $74,000 to the grant amount. The three-year interdisciplinary project involves six engineering departments and four non-engineering departments—biology, earth sciences, chemistry, and computer science. In the past, students had been unable to do realtime computer work due to the cost of standard computer equipment. The project has permitted the development and acquisition of four "stand alone" microcomputer systems at about one-tenth of the cost of standard systems. The laboratory will permit undergraduate students to learn data acquisition systems currently used by large processing industries.

NORTHEASTERN ILLINOIS UNIVERSITY

In 1977, funding in the amount of $50,000 was received by the Department of Geography and Environmental Studies for the training of 30 Chicago-area secondary school teachers in remote sensing principles (the use of photographs of the earth which are taken from satellites and on space missions) and their applications.

In 1977, funding in the amount of $5,000 was received and matched by an equal sum from Northeastern for the purchase of introductory electronics equipment for the Physics II laboratory.

In 1979, the Department of Biology received a grant of $11,300 which was matched by an equal sum from the university for the purchase of a variety of equipment which allows a class of 24 students to conduct individual experiments utilizing the physiograph, a versatile instrument which provides the capability of studying a wide range of standard physiological phenomena in human and laboratory animals.

Since the equipment was acquired, approximately 360 students have taken Vertebrate Physiology, the course for which the equipment was purchased.

APPALACHIAN STATE UNIVERSITY

The general objective of the project is to provide mathematical modeling experiences for undergraduates at Appalachian State University in the mathematical and physical sciences; where real work problems are presented in non-mathematical terms, the mathematical formulation by the student is emphasized problems considered invite solution attempts based on a variety of mathematical techniques and approaches, the time frame for problem solution is suitable for local needs, and studies are suitable for results of "solutions" to be presented in written project reports.

This proposal seeks funding in the amount of $22,114 to design, implement and evaluate a new course for prospective middle school teachers. The course will teach basic physics and astronomy, and the key feature will be the use of inexpensive "string and sticky tape" laboratory equipment and demonstration throughout. The purpose will be to develop student confidence in their ability to develop, and utilize in their later teaching, an abundance of laboratory experiences which cost very little. The experiments will be devised from materials commonly available from any household, supplemented with very inexpensive commercial materials. Typically, a middle school teacher in the public schools has virtually no science budget, and this course will prepare teachers to cope with that reality. A second purpose is to give these teachers a positive feeling about science, brought about by their own success and confidence in doing physics with simple equipment. This positive feeling will, in turn, be passed on to their students.

This proposal requests funds for the acquisition of components of a nuclear radiation spectrometer system to upgrade several upper level undergraduate courses in the area of radiation detection and measurement.

The proposed equipment will be used to continue the improvement of our senior level experimental physics course, to facilitate the expansion of our junior level radiation physics course, and to help establish a meaningful laboratory component in our senior level medical physics course.

STOCKTON STATE COLLEGE

Thank you for your request for information about the effect of NSF science education programs on Stockton State College and the South Jersey community. South Jersey is a rural environment and Stockton State College is the four-year school within about 50 miles. As such it is an important resources to the community. Stockton has received a variety of NSF science education grants in the past.

In previous years, Stockton received funds for the training of secondary school teachers in the local rural area. These teachers were given instructions by the Stockton faculty enabling them to become aware of changes in their disciplines. They were then able to bring this information back to their high schools with them.

Stockton was founded only ten years ago and a very small fraction of the population in this area is college educated. The college has been having substantial impact on the community and NSF Science Education funding has been part of that impact.

NSF Science Education funds are also used for equipment purchases and course improvement. These funds substantially changed our course offerings in physics and enabled us to do a better job in training our students.

SAM HOUSTON STATE UNIVERSITY

Dr. John R. Hilliard, Jr., professor of Life Sciences, directed the program for secondary level science teachers. It totaled $33,157, with 43 participants. Twenty-six schools in 16 different school districts were represented.

"Growing out of this project, six large and ambitious projects in developing wooded areas on school property into outdoor learning centers were initiated and are now being used in instructional programs," says Hilliard.

The project lasted from August, 1977 to May, 1979.

"The investment of an average of $800 in taxpayers funds per participant for funding the overall program has resulted in a widespread influence in improved science education in southeast Texas," says Hilliard.

Dr. Paul A. Loeffler taught in the program for junior high students. He explains the necessity for the program:

"The program was developed to address a problem that exists in, but which is not unique to, East Texas. Many of the area school districts are small rural districts that are generally poorly funded and which, therefore, cannot provide adequate teachers or facilities necessary for satisfactory science training.

"The resultant limited exposure to adequate science training, particularly at the junior high level, often channels students away from later science training and possible careers in science.

"Furthermore, since the enrollment of these districts include a substantial percentage of minorities and disadvantage students are inadvertently guided away from the sciences."

"This program is very effective in inspiring young students to select the pre-college science curriculum that will allow them to grow as tomorrow's scientists," he said.

UNIVERSITY OF NEBRASKA AT OMAHA

Dr. John Karlof, associate professor of Mathematics and Computer Science. Dr. Karloff is presently the recipient of a fellowship to the State University of New York at Stony Brook and Brookhaven National Laboratory as a NSF Faculty development visitor. The goal of Dr. Karlof's fellowship is to develop an expanded department of Applied Mathematics at U.N.O.

"Since there is a shortage of applied mathematics professors and a large demand for applied mathematics college graduates, completion of the program should improve the capabilities of my students in meeting current employment requirements."

In citing the needs of current employment, Dr. Karlof predicts the usage of the program he develops in training seminars for local business. Funding for the seminars would be needed and further Applied studies would also need financial assistance. Dr. Karlof feels most strongly that the budget elimination of Science and Engineering Education programs would have a detrimental effect on the less wealthy institutions.

CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

During academic year 1980–81 at CSUN, "Women in Science and Engineering" program, funded in part through a NSF education directorate grant, recruited, retrained and placed in professional engineering apprenticeships, 52 women who had been out of the scientific labor force for many years.

Participating industry sponsors in that program have included: The Aerospace Corporation; Bunker Ramo Corporation, Electronic Systems; General Motors Assembly Division; Grumman Aerospace Corporation, Pt. Mugu; Hughes Aircraft, Missile Systems Group; Litton Data Systems; Lockheed California Company, Burbank; Northrop Corporation, Electronics Division; Rockwell International, Energy Systems Group; and TRW, Inc., Defense and Space Systems Group.

UNIVERSITY OF MONTEVALLO

At least 300 Alabama high school teachers upgraded their classroom skills through the Pre-College Science Teachers Programs and the College Science Improvement Programs at the University of Montevallo. One of the programs was conducted ten summers. When the program began in the early 1960s, many Alabama high school chemistry teachers were not certified in the specialty because of a shortage of teachers. The program prepared them for their teaching assignments and encouraged them to earn their master's degrees. Ironically, when a public junior college system opened in the mid and late 1960s, the newly trained high school chemistry teachers became the new junior college chemistry teachers.

SOUTHWEST TEXAS STATE UNIVERSITY

To provide funds to buy equipment necessary for establishment of a first-rate Plant Ecology course and to modernize pre-existing plant anatomy and biometry courses.

The plant ecology program is established and will continue to be funded by the Biology Department. Plant Anatomy and Plant Ecology courses will be continued. Without NSF funding, none of these courses could have been equipped as well as they now are with modern equipment.

This grant enabled the Chemistry Department to buy a research chromotography instrument that could not have otherwise been purchased. This purchase allows Dr. W. Rudzinski to conduct research with an instrument with unique capabilities. It further released equipment of lower capability for graduate and undergraduate instruction that would not have been feasible if Dr. Rudzinski would have continued to use the pre-existing department equipment.

STATE UNIVERSITY OF NEW YORK COLLEGE AT BROCKPORT

At the State University of New York College at Brockport, $321,915 in National Science Foundation grants have made possible projects in chemistry, earth sciences, and mathematics/computer science.

A total of 40 faculty members, 8,545 students in natural science courses, and more than 6,000 community members have benefitted from these grants. (The 184 scienece and college level teachers attending a Brockport science education program each have about 35 students in their class for a total community population of 6,440.)

NSF provided $258,773 for Project CAUSE—Comprehensive Assistance to Undergraduate Science Education. This grant made it possible for Brockport to host a conference on microcomputers in higher education that was attended by 142 professionals in higher education, secondary education and business. The conference helped advance the state of the art in undergraduate instruction using computer technology in several disciplines. The proposal identified 2,900 people per year who will receive instruction under this particular NSF grant.

WESTERN OREGON STATE COLLEGE

Western Oregon State College received a NSF CAUSE (Computer Assistance to Undergraduate Science Education) grant in May 1980 for a three-year program emphasizing "Infusion of Computer Science into Liberal Arts and Teacher Education." We are completing the second year of the grant, and we expect the funding to continue for a third year.

Goals of our program include expanding student exposure to computers; expanding faculty knowledge and use of computers; adding an introductory course in computer literacy for the general student; establishing an academic computer laboratory; and developing the curriculum for a minor program in computer science.

So far, 23 faculty members have participated in the program and have received training in ways to introduce use of computers into their regular courses. Projects have been developed in a wide range of disciplines, including mathematics, chemistry, physics, economics, psychology, language, music, education, biology, geology, social science, physical education, library, and dance.

More than 500 students so far have benefitted from the introduction of computer instruction in such areas. Ten more faculty members are scheduled to recieve training this coming summer.

Courses have been added in computer literacy and computer programming and more than 600 students have participated in these courses. College administrators are currently considering introducing computer literacy into the required core curriculum for all college students.

CAUSE grant funds have allowed us to add a computer laboratory that contains 11 APPLE II microcomputers available for use by faculty and students. Progress also is underway in developing a computer science minor for our curriculum.

Overall, then, the NSF grant has helped WOSC make great strides in bringing computers to our students. Because we have traditionally been a teacher education institution (60 percent of our students major in education), we expect the benefits of the CAUSE grant to have long lasting effects upon the future teachers we are training. Special applications for computers in secondary education and special education are being explored by faculty on our campus.

GEORGIA STATE UNIVERSITY

Our Department of Chemistry has been supported by the NSF Science education program CAUSE. This support was used to develop a computer-assisted instructional center for undergraduate chemistry students at the university.

The center consists of 30 micro-computers now in place in the Chemistry Department. It is used as an auto-tutorial system enabling large numbers of students to deal directly with a computer in solving chemistry problems in their study of the subject.

Approximately two-thirds of the funds for the center came from NSF, and the remaining one-third from university sources.

CLARION STATE COLLEGE

Since 1969 Clarion State College, Clarion, Pennsylvania has received numerous grants from the National Science Foundation for the purpose of improving science education. Most grant programs have been designed to provide in service education experiences for teachers of science at the elementary, middle and junior high school, and high school levels. The topics have included elementary science curriculum innovations, environmental science, and human biology. Additional NSF programs designed to disseminate innovations in science education have also been presented by the college. These have included the dissemination of science curricula for the junior high school and curricula in the environmental sciences and, most recently, a program designed to promote science among elementary school principals.

Approximately 600 teachers and school administrators have been directly involved as participants in these science programs. Many more have benefited by the "trickle-down" effect.

The college has found past programs to be very beneficial in meeting the needs of middle grade teachers of science. The individuals, teachers, and administrators that have participated in past programs have communicated positive perceptions concerning the planning, organization, and presentation of the activities that they experienced. The follow-up services and interest provided by the college personnel have proved extremely valuable to our district personnel during the implementation of the ideas generated during their participation.

A healthy respect for federally funded programs has been developed, through willingness to become involved.

During the past several years, Clarion State College has provided valuable and varied in-service programs for their district, with many teachers participating.

In the past several years, Clarion State College has provided a number of valuable educational experiences in the sciences for teachers in Western Pennsylvania. These programs have been possible due to financial support from the National Science Foundation and by the excellent cooperation of concerned teachers.

Clarion State College has done tremendous work in the preparation of teachers for science education. This is and has been possible because of the dedicated teachers and the monetary support of the National Science Foundation. The students and teachers have benefited greatly from programs such as these.

The college has made a major contribution to the Otto-Eldred Schools in two ways. The Clarion graduates employed by this district have excellent backgrounds in science due to the high quality of college preparatory courses. Secondly, the in-service programs provided by Clarion have been practical, pertinent, and have led to positive student and teacher attitudes toward science.

The National Science Foundation could assist Clarion in having a broad impact upon teachers, pupils and the community in general concerning a heightened awareness of one's responsibility for human biology. It is hoped that funding will be made, and that the local schools will be enabled to profit by future in-service.

Over the past several years, at least 40 teachers from the North Hills District have had the benefit of working with the Clarion staff in developing science curriculum for their district. The staff has been instrumental in developing the elementary science program and has had programs for middle school and high school teachers. There has been very good cooperation in assisting the district in the development and implementation of the science program.

The Oil City Area School District also supports the inservice proposal for reasons of past experience with Clarion State College. NSF programs in the past have been carried out with enthusiasm and efficiency. Teachers and administrators have participated and the Oil City students have definitely benefited.

During the various training projects, teachers have learned to design learning environments for hands-on experiencing by children; teachers have become more willing to individualize instruction and to try laboratory activities; teachers have increased their competence with science content, and teachers have been motivated to present science lessons to their students.

Overall experience with other NSF programs administered by Clarion State College has been most positive. Some of the teachers have availed themselves of the opportunity to improve their own teaching strategies. Since many teachers find continuing education to be financially difficult, finding source is of utmost importance so that science teachers may have the opportunity to continue to grow professionally.

The potential impact of a project such as that on Human Biology for teachers of science in grades 5 through 8, could be tremendous. It would impact on teachers, pupils, parents and the community in general. In isolated Appalachian regions, Clarion State College has been instrumental in providing many quality science programs for the teachers, adminstrators and pupils. The programs have provided improved science curricula, teacher in-service programs and technical assistance These services would have been impossible without the many successful science grants and excellent leadership available.

OAKLAND UNIVERSITY

Three recent NSF grants that have helped the Department of Chemistry to keep its curricular offerings reasonably up to date: The RULE grant provided funds to offer improved upper level laboratories and to train faculty to permit the introduction of courses in industrial chemistry and polymer chemistry. The ISEP grant was the latest of a series of NSF Instructional Scientific Equipment grants that the department has received. This particular grant enabled them to add experiments involving thermal analysis to several laboratory courses. The CAUSE grant was as the program title implies, a comprehensive program to improve every aspect of undergraduate chemistry instruction. The net effect of NSF support to this department cannot be over estimated. Oakland University has essentially been able to buy $2 worth of equipment for every $1 of state money. As you know, modern equipment is essential for the training of chemists. Such equipment not only continues to increase in cost but has a useful lifetime of five to eight years. Many of the major equipment items are approaching or have passed their expected life times at the university. Without future NSF support to replace obsolete or wornout items, and add newly developed equipment, other source of funds will have to be found or the training of future chemists at Oakland University will slowly decline in quality.

THE UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE

The Chemistry Department received a Liquid Chromatograph for undergraduate instruction at a cost of $12,250. The number of students benefited annaully is 168.

Under an Urban Environmental Studies Project funded through a $16,942 grant, the university provided an enrichment opportunity for 25 gifted 11th grade students who studied at the university on weekends while still in school. They learned about some of the contemporary problems of cities and studies possible solutions. That program is terminating.

The College of Engineering sponsored a program to encourage undergraduate research through a grant of $15,176. That program is terminating. Five engineering students engaged in research through the program.

A $17,946 grant supported a program to strengthen and update junior and senior high school physical science teachers in the Charlotte area. Some 20 teachers participated. The future of that program would be in doubt without the funding.

Mr. **WALGREN**. Thank you, Dr. Fenster.

Mr. Moss, do you have any questions?

Mr. **MOSS**. No, Mr. Chairman.

Mr. **WALGREN**. Dr. Wenzlau, I would like, if it doesn't put you on the spot, to have you give us specific examples of beneficial change that may have occurred in your university or other universities that you are aware of as a result of NSF science education and support.

Dr. **WENZLAU**. Thank you sir. It is not really putting me on the spot. I would be pleased to try to respond.

Over the years that I have been president of Ohio Wesleyan, we have competed successfully with other institutions for a number of NSF grants. The one that has been clearly most important was one we received several years ago under a program with the acronym CAUSE which is basically a curriculum development program.

It came to us at a time we were in the process of a computer revolution on our campus as has been the case at many institutions. The computer itself was financed by a private grant, but the NSF grant provided the programmatic support we needed to implement that for our faculty and undergraduates.

We are a liberal arts college, but currently roughly 80 percent of our undergraduates are exposed in one way or the other to computer courses or computer applications in courses including those in social science and even in the humanities.

This simply would not have been possible without the generous grant that we received under the CAUSE program of NSF.

I think I agree with Dr. Fenster. Many of us who have been involved with National Science Foundation programs could help in the evaluation of those which have been really important, not only to our institutions individually, but in terms of advancing science. Some of them have not been successful. I think, however, that we can be very helpful to the Foundation and to any committee in trying to assess those education programs which ought to have particular attention during this period of budget restraint.

Mr. **WALGREN**. That is an excellent example.

Dr. Fenster, do you recall anything from your experience or in your institution of a similar nature? I don't know whether your institution is one of those that gets much NSF help or not.

Dr. **FENSTER**. Well, Mr. Chairman, we, too, were the recipient of a CAUSE grant from NSF which was a very highly successful program. The instructional equipment programs which occasionally have resulted in some support for our institution have been extremely successful.

Again there is a high leveraging effect of those programs when we seek external support. Certainly in the precollege programs, the NSF support there was seminal. It was critical in getting the program started. Federal support is still very important for those programs, but as the report on our Center for Precollege Programs indicates, the majority of the support now is outside of the Federal area and is largely in the corporate sector, the corporations seeing a vital connection between the outcomes of that program and their own interests.

Certainly those programs, CAUSE, instructional equipment. and precollege, have been very important to us at NJIT. By the way, NJIT also receives a considerable sum in support of research from NSF. But I think the education part of the mission and the research part of the mission are both vital and that the educational part of the mission must be increased and not at the expense of research which plays a crucial part in the overall NSF mission.

Mr. WALGREN. Ms. Klein, I am not going to ask you to describe the transforming role that the National Science Foundation Institutes in Science Teaching may have had on your life. The record reflects the importance of these programs over the years which I am sure you are very well aware of.

I think you all are sensitive enough to know Dr. Slaughter probably would not have come in and recommended an elimination of most of his science and education programs if he hadn't had some influence from other sources.

The problem of maintaining a healthy science education program at NSF is a perennial problem. It didn't just crop up this year. We may need to rethink our strategy on this to some degree. I was reading over some of the material that Dr. Slaughter submitted indicating the thinking about alternatives that would be available to them, including the establishment of this Commission and the need to select some high leverage activities where they could have maximum effect on science education with minimum amount of dollars.

Of course, this is an appropriate strategy at this time. I am going to read to you some suggestions—you may have seen this, I don't know—that he has and ask you to comment as to whether these are appropriate and whether you would support this kind of approach if there is no more than minimal funding for science education.

He says in his, this is Dr. Slaughter, I am quoting from a letter to the Board, his Board, I guess——

> The National Science Foundation can provide support in selected areas where significant improvement in science engineering education is possible with limited investment. Example: Materials and publications for science teachers in schools and colleges to convey advanced knowldge and new technology resulting from basic research and industrial technology.
>
> (b) Recognition of excellence of both students and teachers.
>
> (c) Building opportunities for interaction between science teachers and scientists and engineers in colleges, universities, and industries.
>
> (d) Regional resource centers to coordinate and integrate such activities as local needs assessment, in-service training, encouragement of science interests in minorities and women, and local leadership development.

I ask you to comment as to whether or not these are not useful activities that the Foundation might be engaged in given limited funding?

Dr. **Wenzlau**. My comments would be that they are a far cry from what the National Science Foundation Education Directorate has been involved in. I particularly do not see—I think it is very useful in one sense to be able to recognize outstanding students and teachers in science; but it doesn't seem to me that that really gets at the problem.

The problem is generating more outstanding young people who are well educated scientifically, who can then proceed to graduate work. It does not seem to me that any of these things he has spoken about really focus very directly on those particular needs.

I think that we have a very good basic educational system in place, but it has gotten behind. We need to work within that system in supplying needs, both personnel needs for upgrading faculty and equipment—as I mentioned in my testimony—is becoming obsolete.

That is as much a problem on my campus and campuses like mine now as getting new equipment. We had very generous grants 10, 15 years ago under a much larger NSF education budget for scientific equipment, for instruction, and that equipment is simply wearing out, becoming obsolete and we need to replace it.

Mr. **Walgren**. Dr. Fenster.

Dr. **Fenster**. Thank you, Mr. Chairman.

Moreover, to add to the remarks of Dr. Wenzlau, the program elements cited don't appear to me to be the kind of programs which are going to benefit from the high leverage of external support. It seems to me that the equipment sort of things, the precollege programs, the course improvement programs, programs such as CAUSE are more likely to engender external support, particularly of the corporate and foundation community, than the kinds of programs that were quoted.

Mr. **Walgren**. They meet the criteria of limited investment, however, do they not?

Dr. **Wenzlau**. Yes, I think we would agree with that.

Dr. **Fenster**. It is hard to quarrel with that, Mr. Chairman.

Mr. **Walgren**. Ms. Klein, do you have a comment?

Ms. **Kelin**. The one I would maybe concur with that might do something would be the regional resource centers, but how big are those regions and with travel for anybody to take advantage of those at this point in time seems to be rather questionable. That would be the only one that I would see that could be of some value.

Mr. **Walgren**. We are in a difficult situation here. I think the committee, if it holds true to form, will probably want to try to maintain as much of a science education program as is possible, but we can't be sure that it will be a winning battle. It is one of those difficult situations, and if we lose the battle, I think we are all interested in maintaining as adequate a program as we can with whatever we have got available. I suspect Dr. Slaughter feels that way, too.

In view of the hour, I am not going to pursue further questioning. I am very grateful to you. If we have further questions—although I think we have an excellent record on this to substantiate our preconceived positions already—we will ask you to respond in writing to those questions.

Thank you very much.

Dr. **Fenster**. Thank you very much.

Mr. **Walgren**. The subcommittee will be adjourned.

[Whereupon, at 4:35 p.m., the subcommittee adjourned, subject to the call of the chair.]

1983 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

THURSDAY, MARCH 4, 1982

House of Representatives,
Committee on Science and Technology,
Subcommittee on Science, Research and Technology,
Washington, D.C.

The subcommittee met, pursuant to recess, at 9:10 a.m., in room 2325, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Present: Representatives Walgren, Shamansky, Dymally, Heckler, Gregg, and Skeen.

Staff present: Paul C. Maxwell, science consultant; and Donald L. Rheem, minority technical consultant.

Mr. **Walgren**. Ladies and gentlemen, good morning. I want to apologize for being a little late.

This morning is our final hearing before the subcommittee begins to markup the bill authorizing expenditures by the National Science Foundation for fiscal year 1983.

Today we will look at programs in several problem areas: Women and minorities, the handicapped, and instrumentation.

The "Science and Technology Equal Opportunities Act," as part of the fiscal year 1981 National Science Foundation Authorization Act, emphasized that under-represented groups should have an equal opportunity to participate in science and technology.

The act recognized barriers to women and minorities caused by the impact of the advance of science and technology. It directed the National Science Foundation to support and initiate activities and programs to improve the access to and increase the participation of women and minorities in science and technology.

The National Science Foundation responded by creating two new programs for women—the national opportunity grants and visiting professorships for women. Also, the minority research initiation program was created, and an existing program, research improvement in minority institutions, was strengthened. These programs were part of the cross-directorate directorate in the Foundation.

However, before these new programs could get started, they were eliminated in the March 1981 revision of the National Science Foundation fiscal year 1982 budget request, and, as was pointed out at our hearing last Thursday, the women, minorities, and handicapped program that had been in the science and engineering education directorate was zeroed at that time.

Only by the particular attention of the Congress and the diligent efforts of the Foundation's Director was some of the funding replaced for fiscal year 1982. From a zero total requested by the National Science Foundation, $2.7 million was put back in for women and minorities. NSF has now transferred these programs to a subactivity of the directorate, STIA, called coordinated agency-wide research activities (CARA).

The National Science Foundation fiscal year 1983 budget request calls for an increase to $5.5 million in the CARA programs for women and minorities. Although this is still a far cry from the original level of $9 million for fiscal year 1981, it is certainly an improvement over last year's request for zero funding.

We hope today to look at some of these programs as well as at the increasing importance of making better use of the 60 percent of our population represented by women and minorities.

With respect to the handicapped programs, it is important to note that the National Science Foundation has eliminated the last remaining research program for the handicapped.

Despite the importance of that work, which has led to, among other things, synthesizing speech and improved prosthetic devices, that division of engineering has been zeroed out. We will want to look at that program carefully in drawing up the final budget.

Turning to the last area of our inquiry today, the problems of instrument obsolescence in research are not of recent vintage. Indeed, that is what makes the circumstances that now face us in research and education appear so critical.

As early as 1972 a National Science Foundation survey recognized there was a major shortage, and published reports, editorials, and reviews have reemphasized the issue with increasing frequency and urgency.

The Foundation has recognized that investment in this area is a high priority item, and this is reflected to some extent in the budget request. However, it is nowhere clear what level of funding would be required to effectively address the real needs, nor are any real initiatives being proposed.

The failure to provide an accurate evaluation in the past is at least partially responsible for our present difficulties. It seems to me personally, that we should certainly delay no longer coming to grips with the issue. We must also consider some imaginative management strategies to deal with this very large problem.

[Material referred to follows:]

HEARING SUMMARY EXTRACTS

NATIONAL SCIENCE FOUNDATION AUTHORIZATION FOR FY 1982

CROSS DIRECTORATE PROGRAMS AND THE DIRECTORATE FOR SCIENTIFIC, TECHNOLOGICAL, AND INTERNATIONAL AFFAIRS

The Subcommittee held one day of hearings on the NSF programs conducted in the cross directorate and the scientific, technological, and international affairs areas (March 17, 1981). Witnesses were:

- Dr. John Slaughter, Director, National Science Foundation
- Dr. Don Langenberg, Deputy Director, National Science Foundation
- Dr. James C. Fletcher, Professor, University of Pittsburgh and former head, National Science Foundation Transition Advisory Team for President Reagan
- Dr. Allan Bromley, President, American Association for the Advancement of Science
- Dr. Philip Handler, President, National Academy of Sciences

A. ELIMINATION OF THE CROSS DIRECTORATE PROGRAM SUPPORT

Dr. Slaughter announced that the cross directorate program support would be eliminated in FY 1982. Activities such as research instrumentation, research facilities improvement, and research initiation programs for women and minorities were among the activities that would be eliminated. However, Dr. Slaughter emphasized that he would try to see some of these activities continue at lower support levels through the research programs.

B. REDUCTIONS AND TERMINATIONS OF INTERNATIONAL PROGRAM SUPPORT

Dr. Slaughter outlined several reductions and terminations in the international programs. Though the U.S.-China bilateral program would be continued at its former level, the U.S.-U.S.S.R. program would be sharply reduced in consequence of the recent invasion of Afghanistan.

Another major area slated for reduction, according to Dr. Slaughter, was the International Scientific Organizations and Resources Program, which supports the International Council of Scientific Unions and the International Institute of Applied Systems Analysis. STIA support for both of these organizations would be terminated, though the former would continue to receive some support through the research directorates at NSF.

C. CRITICISM OF THE REDUCTIONS AND TERMINATIONS OF SUPPORT FOR INTERNATIONAL PROGRAMS

Dr. Bromley stressed the importance of the international programs to the interests of U.S. science, saying that it would be short-sighted to isolate the U.S. from the science advances of the rest of the world. He said he was pleased to hear that some support would still be forthcoming for the International Council of Scientific Unions.

Dr. Handler pointed out that the system of having the research directorates at NSF provide support for the International Counoil of Scientific Unions had proven a failure in the past, and that he shared Dr. bromley's strong support for maintaining broad and deep international contacts in science. He voiced particular concern about the decision to stop supporting the International Institute for Applied Systems Analysis. He felt that this was a very valuable and unusual international cooperative effort that had produced valuable results and that it would be a serious mistake to terminate it.

HEARING SUMMARY EXTRACTS

NATIONAL SCIENCE FOUNDATION AUTHORIZATION FOR FY 1982

ENGINEERING AND APPLIED SCIENCE

The Subcommittee held one day of hearingson the Engineering and Applied Science Directorate (March 5, 1981). The following witnesses appeared:

- Dr. John Slaughter, Director, National Science Foundation
- Dr. Don Langenberg, Deputy Director, National Science Foundation
- Dr. Lewis Branscomb, Chairman, National Science Board and Vice President and Chief Scientists, IBM,, Inc.
- Dr. Robert A. Frosch, President, American Association of Engineering Societies
- Dr. H. W. Paxton, Vice President-Research, United States Steel Corp.
- J. Robert Havlick, Director, Florida Innovation Group
- Dr. Dwight Baumann, Director of the Center of Entrepreneurial Development and Professor of Engineering Design at Carnegie-Mellon University

A. REORGANIZATION OF THE DIRECTORATE

Dr. Slaughter announced that the Directorate for Engineering and Applied Science had been dissolved. The applied science programs and support would henceforth be conducted as part of the research program activities associated with each basic discipline. A new Engineering Directorate would be formed to support research in engineering. Dr. Slaughter said that since basic and applied science are virtually indistinguishable, this new arrangement would promote applied science most effectively, and offer more concerted attention to the needs of engineering.

B. FORMATION OF A DIVISION OF INDUSTRIAL SCIENCE AND TECHNOLOGICAL INNOVATION

Dr. Slaughter announced the formation of a new division of industrial science and technological innovation to house four closely coordinated programs:

- Industry-University Cooperative Research Projects
- Small Business Innovation Research Program
- Industry-University Cooperative Research Centers
- The Innovation Processes Research Program.
  These were aimed at the problem of declining productivity and innovation in the United States.

C. THE NEED FOR MORE ENGINEERS AND GREATER INNOVATION

All of the remaining witnesses pointed with alarm to the combined problems of low innovation and the lack of sufficient numbers of engineers. Dr. Frosch laid out the elements of the problem of insufficient numbers of engineers by saying that salaries for newly graduated engineers are so high that few want to continue with graduate study. Also, the lure of high industrial salaries, coupled with the increased numbers of engineering students and the fact that many faculty positions cannot be filled so that teaching loads are high for engineering faculty, leads to an exodus of faculty to industry plus an inability to refill faculty facancies. In addition, teaching equipment and research equipment are in great need of refurbishing, leading to a further disenchantment for faculty to stay in universities.

The problem, according to Frosch, could be "improved by an infusion of Government assistance, but the amount appears to be very large." He went on to estimate the total assistance needed for instructional research equipment at between $1 and $2 billion over the next ten years, or about $200 million per year. This, he pointed out, would not deal with the problem of academic salaries being too lwo compared to those of industry. He called on industry to assist in funding engineering education, and to provide avenues for students and faculty to obtain industrial experience. He called on NSF to facilitate such programs, but did not expect NSF to have sufficient funds to overcome the major financial problems of refurbishing engineering instructional and research equipment. He also called on NSF to establish cooperative university-industry research ventures.

Dr. Paxton stated that he had found university-industry cooperative projects valuable for certain endeavors, such as overcoming a particular problem in research. However, he did not feel that such cooperative efforts would necessarily lead to innovation, because "innovation is most commonly market driven." They might possibly lay the groundwork for later innovation, though.

Dr. Paxton was critical of industry-university cooperative research centers. He felt that they "tend to take on a life of their own" and that there was reson to doubt "whether these can be effective in meeting the needs of industry in generic technologies."

Dr. Baumann made a very strong statement to the effect that the greatest difficulty with engineering in the United States is that it has attempted to copy science when its basic function is not actually scientific. He felt that engineering "is not science, in the sense of scientific discovery; but rather, it is simply mathematical modeling and while it is a good skill to learn and it is a good skill to teach; one should not call it 'pure science'." He said that engineering involved great amounts of intuition, skill, and judgment, as well as modeling, but was not science. He criticized the Engineering Directorate at NSF for seeking to make engineering too scientific and for failing to train engineers for the types of problems needing solution in the real world.

Mr. Havlick spoke of the importance of NSF sponsorship to his group's efforts to influence State and local governments to be more innovative in handling their functions. He pointed out that NSF support not only helps to reduce the financial risk to governments buying the services of his group, but it also gave the group credibility with officials who must purchase those services.

Mr. **Walgren**. We have a number of important witnesses here this morning. We certainly appreciate your coming to help the subcommittee complete its evaluation of the National Science Foundation program and make a record on which to base its judgments in trying to shape the authorization this year.

I would like to recognize briefly for opening statements other members of the subcommittee present, if they desire.

Mr. Shamansky?

Mr. **Shamansky**. Thank you, Mr. Chairman.

I just want to make a few points and note that last Friday I took a tour of Ohio State University's physics and chemistry labs. I went to a laboratory that I took chemistry in, and I graduated 35 years ago. It had not changed at all; I felt right at home.

I am not saying that gleefully; it is a problem. It was estimated that to bring the instrumentation up to date would cost approximately $85 million, and that is not an inflated figure.

That is one major university as representative of the problem. You cannot continue in this vein.

I would also like to say that mine was the last class at Harvard Law School in which there were no women students. The first one came in the fall of 1950, and now the female population of the student body is about 30 percent. That means that we are eliminating great talent, as you mentioned in your statement. I think that has got to be changed.

As someone who is physically handicapped myself, I think it is vital to continue research the results of which permit people to lead fruitful lives, and it is a good investment.

Thank you, Mr. Chairman.

Mr. **Walgren**. Thank you, Mr. Shamansky.

Mr. Dymally?

Mr. **Dymally**. Thank you, Mr. Chairman. I will save my time for questions and answers.

Mr. **Walgren**. Mr. Gregg?

Mr. **Gregg**. I have no opening statement, thank you, Mr. Chairman.

Mr. **Walgren**. With that, I want to welcome representatives responsible for the direction of NSF on a day-to-day and year-to-year basis: Dr. John Slaughter, the Director the National Science Foundation; and Dr. Donald Langenberg, the Deputy Director of the National Science Foundation.

Gentlemen, we are pleased you were able to come back. We especially appreciate hearing from both of you inasmuch as you are the true decisionmakers in the direction the Foundation takes. We feel we are really talking to the proper people when we have you before us. We appreciate your coming.

Dr. Slaughter?

STATEMENT OF DR. JOHN B. SLAUGHTER, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. **Slaughter**. Thank you, Mr. Chairman, and members of the subcommittee; we are pleased to be here again because we value these opportunities to share with you the concerns and aspirations of the National Science Foundation and to display NSF's programs for your consideration as you address the critical issues facing science and technology in this country.

Dr. Branscomb regretted that he could not be with us today. He asked me to express his appreciation also for the in-depth examination you are providing of the NSF budget.

Dr. Langenberg and I will discuss two items today. I will discuss primarily the issues of women, minorities, and handicapped; Dr. Langenberg will discuss the issues of instrumentation.

I propose, Mr. Chairman, that Dr. Langenberg present his comment now, that we discuss and answer questions about instrumentation, and then that I give a brief statement concerning the women, minorities, and handicapped portions of the NSF program.

Mr. **Walgren**. Let me at this point ask Mr. Dymally to take the chair. I have another really important commitment. I wish I could be here, and I will study in great detail what you present. It is not for lack of interest, but I am afraid I have to go.

Mr. **Dymally** [acting chairman]. Mr. Chairman, before you leave, I want to tell you I like it up here. [Laughter.]

Dr. Langenberg?

STATEMENT OF DR. DONALD N. LANGENBERG, DEPUTY DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. **Langenberg**. Thank you, Mr. Chairman, and members of the subcommittee.

As Dr. Slaughter mentioned in his testimony last week, we are presenting a tightly constructed budget, one whose preparation depended on a careful assessment of NSF priorities and needs. In the course of that assessment, we looked closely at instrumentation and facilities needs relative to other research opportunities and needs.

As the members of this subcommittee know, over the past few years the Foundation has placed a high priority on upgrading scientific and engineering instrumentation in the Nation's colleges and universities. This equipment is necessary for conducting forefront research in a wide variety of disciplines. The need this year is no exception. I would like to take a few moments to describe the general nature of the problem we are facing and to describe what the administration is proposing in the Foundation's fiscal year 1983 budget.

There is an emerging consensus—many would say it has emerged—that the Federal Government, private industries, and universities all see a critical and growing need to replace obsolescent, worn-out research apparatus and laboratory facilities in the Nation's research universities.

There is strong qualitative evidence that the problem is pervasive and rather large in scope. A rough, but reasonable, estimate of the lower level of the deficit—and by that I mean what would be needed to catch up, to get back up to speed in the Nation's university research laboratories—is about $1 billion. Some have placed the upper boundaries of that deficit in a range of $3–4 billion.

I might just interject a word here about the accuracy of these estimates. They are not high, and I think that high accuracy on these estimates is probably unobtainable because there are significant differences in the answers that one gets to questions such as:

What could the Nation's research universities use?

What would they need to keep them at the forefront of the world's research efforts?

What must they absolutely have to remain effective performers in research?

It is really difficult to get accurate estimates, but something in the range from $1 to $3 or $4 billion is not unreasonable. You might think of it as a $2 billion problem, plus or minus a factor of 2. If this general assessment of the scope and the nature of the problem is correct, it means that the productivity and efficiency of the Nation's academic research enterprise has already declined and will continue to decline.

Most of modern scientific and engineering experimental research is heavily dependent on instruments. Capital investment in advanced instrumentation and the facilities to house it are necessary if we are to maintain the national position at the forefront of a wide variety of disciplines and to get the maximum productivity, I might add, from the total investments in support of research. It will do us no good to support scientists and engineers if we cannot provide them the tools they need to perform.

Perhaps to get a better idea of the nature and magnitude of the problem, the Foundation is exploring the development of a system of indicators on the status of university research laboratories and equipment. We have preliminary data derived last fall from a kind of pilot program to see whether such a system could be developed.

We looked at a sample of 38 institutions, and we found a number of interesting things. About half of those instrumentation holdings were acquired 6 to 10 years ago, and shared use of instruments among researchers and departments is common.

Even though we need to do considerably more work to develop better quantitative information, some immediate action can be taken. I would like to discuss several steps taken during the past year and then comment briefly on NSF's current budget request as it pertains to instrumentation.

Given that efforts to upgrade research hardware are clearly necessary, but given also that the Nation faces serious economic problems and budgetary constraints, it seems clear that any solution to this problem must involve not only the National Science Foundation but also other Federal agencies—and not only the Federal Government but also academic research institutions, State governments, and industry.

Last August, in an effort to get some idea of the Federal response to the problem, with the support of the Director of the Office of Science and Technology Policy, we convened an interagency working group on university research instrumentation. Its purpose was to begin reviewing the nature and extent of the problem and to explore several schemes for a possible Federal response. Apart from the National Science Foundation, represented on that interagency group were the Department of Agriculture, the Department of Defense, the Department of Energy, the National Aeronautics and Space Administration, and the National Institutes of Health.

The interagency group quickly reached agreement that inadequate university research instrumentation was indeed a pervasive and endemic problem and that the Nation would benefit from its alleviation. Because the agencies represented in the group have a wide variety of mission responsibilities, it was concluded that an approach involving interagency cooperation and coordination, rather than a single integrated governmentwide program, would be most appropriate.

An agency-specific strategy allows us to match individual agency priorities, to make careful comparisons of the relationship of instrumentation needs to other research requirements, and to form a better and more specific response to the special needs of different scientific areas.

You will find in the fiscal year 1983 budgets of those represented agencies some responses to the instrumentation problem. I would note that the Department of Defense is proposing a $30 million special initiative to build the university research base in disciplines related to its own scientific programs.

NASA is having its program officers give special attention to project-related instrumentation requests. NIH plans to increase slightly its current instrumentation programs. The Department of Energy is instructing its program officers to protect budgets for instrumentation in its research awards, and NSF research programs are increasing their support for major equipment and other instrumentation by 11.5 percent above fiscal year 1982 to a total of $95 million.

We expect that the interagency working group will continue to meet from time to time and will continue to monitor the continuing Federal response to the instrumentation problem.

Within the NSF total that I mentioned, each scientific area in the Foundation is responding to the needs of its disciplines. The total increases in equipment and instrumentation support relative to fiscal year 1982 range from 4.8 percent for the U.S. Antarctic program to almost 24 percent in engineering.

Some programs have increased their support to investigators on regular research grants. Others are providing instrumentation for shared use through various mechanisms. Some provide research instrumentation and facilities that are too specialized and expensive to warrant duplication in special programs.

You will find in the prepared statement a list of some examples of responses in the Foundation to the instrumentation needs; I will not go through them here. They include, incidentally, continued funding for research instrumentation for use by faculty at 2- and 4-year colleges.

These activities will certainly not eliminate soon the need for major renovation of advanced scientific and engineering instrumentation in the universities. We think they do represent a realistic and meaningful approach at a time when economic recovery is a major national concern.

What has been done by the Foundation in fiscal year 1982 and is proposed for fiscal year 1983 calls attention to the need for continuing effort in this area. It provides for a balance across areas of science, meets the most critical research needs within a constrained budget, and allows the exploitation of new ways of providing the instrumentation essential to full use of the scientific and engineering manpower pool.

I might just mention that NSF is exploring some ideas for stimulating industry to consider donating instrumentation to research universities in coordination with the award of NSF grants. I would be pleased to answer any questions that you have.

Dr. **Slaughter.** Mr. Chairman, I would propose that perhaps you might want to go ahead and ask questions on instrumentation, and then I will come back on the women and minorities, if that is all right.

Mr. **Dymally.** That is fine.

Mr. Gregg?

Mr. **Gregg.** Do you have a cost estimate for the instrumentation of our science education institutions?

Dr. **Langenberg.** The number that I suggested was $2 billion, give or take a factor of 2.

Mr. **Gregg.** Assuming that to be true, your proposals are just a flash in the pan. What else should the Congress do in this area beyond the National Science Foundation?

Dr. **Langenberg.** You might wish to bear in mind two items as you consider congressional responses. One is, of course, that the problem is large. It is not a problem that necessarily needs to be or perhaps even can be addressed in a short time. You should think in terms of several years.

Second, the problem need not, and perhaps ought not, be solved entirely by the Federal Government. Surely the research universities must take a role in solving that problem, and surely the private sector, for a variety of reasons, needs to take a role in solving that problem.

Third, I would suggest that one needs to look at the entire university research funding mechanism in the Federal Government. It is, I think, inappropriate to look at one agency in isolation, but one needs to look at all of them. In fact, it is to facilitate an awareness of what is going on across the Government that we established the interagency working group.

It seems to me a variety of mechanisms could be considered for helping solve the instrumentation problem. Some of these Congress has already been involved in. They include direct provision of funds from Federal research funding agencies to universities for instrumentation, but another potentially fruitful congressional action has been change in the tax law—tax incentives for donation of instrumentation by industry to universities. I hope we can devise a way to exploit these incentives.

Mr. **Gregg.** You mentioned that there is a lot of sharing within the university communities. Your interagency task force is obviously sharing the distribution of dollars currently. When you distribute the instrumentation dollars, do you impose any limitations which reflect the need for cooperation? Are there any strings attached?

Dr. **Langenberg.** There are no strings attached so far as the title is concerned. In almost all cases where the National Science Foundation provides equipment or instrumentation, the title passes to the grantee.

There are, however, means of encouraging cooperation and sharing in a variety of ways. I would mention, for example, many of the larger facilities supported by NSF, which are operated as user facilities for an entire community of scientists. I am thinking, for example, of the astronomical observatories and the regional instrumentation facilities intended to provide services and instrumentation to a wide variety of users. I would add that in many cases instrumentation is widely shared without any particular encouragement from NSF, simply because there is such a shortage of instrumentation and because it is essential.

Mr. GREGG. Is there anything you can suggest in this area that should be done or should not be done relative to making the instrumentation go further through shared use?

Dr. LANGENBERG. The mechanism is already in place to strongly encourage shared use of instrumentation where it really makes sense. We found, for example, in our recent surveys that almost 90 percent of all of the institutions we have surveyed have central pools of equipment which are made available widely around the institution.

The mechanisms for reviewing and for auditing the university business systems generally include a provision to encourage good inventorying of equipment. In various of NSF's programs we even require certification that an instrument requested on a proposal is not already available within the university. NSF, other agencies, universities, and scientists themselves are concerned about the use of existing instrumentation.

Mr. GREGG. Thank you.

Mr. DYMALLY. Thank you very much.

Dr. Langenberg, when you make a grant to a grantee, they basically say to you, "Trust me." Do you have any accountability built into that? How do you know that they have spent the money on instrumentation? Is there any follow-up, any inventory?

Dr. LANGENBERG. There is, of course, financial accountability provided by the usual audit process. All of NSF-supported institutions are audited with respect to their expenditures of Federal funds and research funds in particular. Most institutions are audited by one of two cognizant audit agencies, either the Department of Health and Human Services or the Defense Contractor Audit Agency.

Scientific accountability is accomplished through a variety of mechanisms. For example, where a grant has been made and where the principal investigator wishes continuing support after the end of that grant, he or she will come back to the Foundation or perhaps to another agency with a proposal for further support. In the process of making that proposal, he or she will describe fully the progress made under previous support. Whether the new proposal is recommended for award generally will depend heavily upon what kind of progress has been made.

Mr. DYMALLY. I am one of those skeptics about enlisting the support of the private sector, although I do not discourage your effort in that direction. But if you proceed in that direction, it seems to me you almost need a fulltime staff to urge the large corporations to give to the large universities that are research and science oriented.

What about the small universities and colleges? Do they get lost in the cracks? What guarantee do you have that the private sector is going to be generous enough to give to a small college, as opposed to one of the large State universities or the Ivy League institutions?

Dr. **Langenberg**. The Foundation is certainly in no position to guarantee that the private sector will do anything, but we can certainly encourage the private sector to support research. We can encourage industry, for example, to make use of incentives provided, in the tax legislation. The distribution of their responses to those incentives is largely in the hands of the private sector. As you know, many industries often concentrate their giving on the local area. If that local area includes small colleges, those colleges do often benefit.

I do not have the figures at hand, but by no means are all of the current charitable gifts to institutions of higher education in this country concentrated in the few large universities.

Mr. **Dymally**. Dr. Slaughter?

Dr. **Slaughter**. I want to emphasize Dr. Langenberg's point, with which I agree fully. Most of the students graduating from engineering schools now and going to work for industry are graduating from institutions not necessarily included in the top research institutions. The students are coming from several good State universities and several smaller 4-year institutions that emphasize an undergraduate education.

Industry also feels a responsibility to those institutions, because they are producing a significant share of industry's human resources. So I agree wholeheartedly that an industrial initiative would certainly consider the sources of a goodly share of their engineers and scientists who graduate from baccalaureate programs.

Mr. **Dymally**. Doctor, do you estimate that we need a minimum of $2 billion to upgrade our instrumentation? Among you, Defense, and other sources, we only see about $100 million for this purpose in this year's budget. At that rate, how much time do you think it will take? Will you and I be gone by then?

Dr. **Langenberg**. That is quite likely. It will take a long time at that rate.

The $2 billion, by the way, is probably not a minimum. It is probably something like a geometric mean; $1 billion is probably the minimum. But one can do a simple calculation to see what the national scale for a program that would meet the apparent needs might be as follows:

If it is $2 billion and if one imagines five years as a reasonable time to undertake such a program, we are talking about $400 million a year. If one imagines that the role of the Federal Government ought to be roughly balanced by the role of the other participants—the universities and private industry—then let us simply split the $400 million and say that we ought to be seeing $200 million from the Federal Government per year and $200 million from other sectors. We are not there, but we are making at least a reasonable incursion into the total needed.

Mr. **Dymally**. I think it is proper to view this situation as somewhat critical. In the other areas—science and engineering—the NSF has proceeded to set up a commission to study the problem.

Do you have any immediate or long-range plan to study this crisis, so that Congress and the administration become fully aware of how critical the situation is?

Dr. **LANGENBERG**. We have no plans to establish a commission. We do have plans to continue monitoring and studying the problem. I have mentioned some efforts underway to devise more accurate and more comprehensive indicators of the state of instrumentation. He would expect the efforts of the interagency working group to be continued.

The National Academy of Sciences is having a meeting in a week or so to consider what role the academy might wish to play in keeping track of the problem. All agree the problem is critical. You are absolutely correct; many institutions and many people will be tracking it, including NSF.

Mr. **DYMALLY**. Mr. Walgren had a question, and I am going to ask Dr. Maxwell to ask the question for Mr. Walgren.

Dr. **MAXWELL**. Thank you, Mr. Chairman.

There are a couple of concerns that Mr. Walgren has had, I think, relating to the instrumentation initiatives and instrumentation concerns. First of all, I think he wanted to know whether or not the National Science Foundation has in place at the moment any mechanisms for actually determining whether money provided for instrumentation in individual research grants—which will total $95 million, as you suggest, in the budget—actually is allocated. Is there any way for you to determine if in fact that money has been used for that purpose?

Dr. **LANGENBERG**. Not in great detail. It happens that the financial reporting requirements currently in use—if I am correct, we are following procedures established by OMB for such reporting—simply do not include enough specific detail so we can track specifically how funds provided by NSF are used; that is, we have no way of determining whether money specifically budgeted for a particular piece of instrumentation actually was used to buy that instrumentation.

Dr. **SLAUGHTER**. Let me see if we understand your question, Dr. Maxwell. Is your concern more about safeguards within the Foundation to ensure that the directorates expend money for instrumentation from the research budgets?

Dr. **MAXWELL**. It seems to me that it is not really an accountability problem but it is part of a broader problem. The National Science Foundation comes up and points to the independent research grants, and a certain percentage of that is being proposed to be spent toward instrumentation. Yet, over the past decade we have seen a steady decline in instrumentation needs of the researchers.

It appears that what happens is that a researcher does propose that he will spend 30 or 40 percent of his grant for instrumentation. During the normal process the funding proposal is reduced, for various reasons related to the peer review process and the program managers' decisions. The investigator, when he gets his final proposal in hand, has to make decisions as to whether he buys instrumentation or simply repairs what he has on hand and keeps on the graduate students or other researchers that he wishes to support as part of that research.

It appears that what is happening is that the instrumentation is not procured as indicated in the original grant. In his renewal proposal the investigator probably again requests money for instrumentation, and the process repeats itself, the end point being that, after a period of several years, the instrumentation is not purchased, funding goes forward as per normal, but a gradual deterioration appears to happen.

The question here is one of followup. Perhaps in the renewal process, would it be possible for the Foundation to evaluate whether the instrumentation, as requested in the original grant, were actually purchased? If not then can a requirement be made asking if the original instrumentation purchase has occurred.

I would point to a study by the GAO in evaluating this process in comparison with the National Institutes of Health. The National Institutes of Health do not have a problem in determining whether or not money is actually spent for instrumentation. We do not understand why NSF has a problem when other institutes in the Federal Government do not.

Dr. **LANGENBERG**. First a general comment: to the extent possible and reasonable, we like to provide NSF grantees some flexibility within the granted budgets.

I do not doubt that, within the limitations imposed, in many cases funds originally requested for equipment are occasionally used for support of students. I also do not doubt that in some cases, perhaps an equal number of cases, funds flow in the opposite direction.

Our estimates of funds expended on instrumentation as opposed to other elements within a research project are based on the final approved budget for the project, not on a detailed post—facto accounting of exactly what was spent on what. We simply do not have in the Foundation that kind of information.

You have, however, put your finger on an important aspect of this problem. One of the reasons we have the problem is that over the past decade and a half the scientific community itself has behaved in such a way as to keep instrumentation expenditures below what they should have been in a wise, long-range planning strategy.

Dr. **MAXWELL**. Would you say that perhaps one solution to the problem would be to earmark a certain percentage of the research and related funds specifically for instrumentation?

Dr. **LANGENBERG**. The dependence of different disciplines on instrumentation built, purchased, or developed or whatever, vary so much that I would be opposed to earmarking specific fractions of the research and related activities budget for instrumentation.

I would much prefer to gently but persistently urge both the Foundation staff and the scientific community itself to bear more clearly in mind the instrumentation needs and urge those expenditures upward.

Dr. **MAXWELL**. Thank you, Mr. Chairman. We will probably have some more questions for the record, but we will leave it at that.

Mr. **DYMALLY**. Mr. Shamansky?

Mr. **SHAMANSKY**. Thank you, Mr. Chairman.

I am really intrigued at your response that the scientists themselves were guilty of neglecting the whole issue of instrumentation. As you know, I am very concerned about that.

If there is something about the profession or the way it is run that would cause this to be repeated, then we will be right back in the soup again. So I am asking you, what are the reasons for that, as far as you can tell?

Dr. **Langenberg**. Mr. Shamansky, you are looking at a scientist who has been guilty of the sin I just described.

Mr. **Shamansky**. Then you should be the one to tell us.

Dr. **Langenberg**. Let me give you then my personal view of the psychology—the sociology, if you will—of that phenomenon.

I speak now of scientists old enough to have been in the early stages of their scientific careers during the early 1960's. They began those careers when funding for research was exhibiting real growth at significant rates—in some cases, 10 or 15 percent a year.

Under those boom conditions, rarely was it necessary to sit down and ask hard questions about how best to spend constrained resources. Scientists generally had enough funds to support their graduate students buy new instrumentation, and outfit the laboratory for a brand new experiment.

When research funding reached a plateau in the late 1960's, it became necessary to ask those questions, but the recollections of the boom times in the minds of many scientists were transformed into a feeling that while times were temporarily hard they would inevitably get better. The good old days would return.

Therefore, the best strategy in the short term—and of course the problem would disappear in the long term—was to support those graduate students, to keep the old instrumentation running for yet another year—"We can still do good science with it"—to put off starting in a new direction and therefore having to outfit a brand-new laboratory for another year, until things got better.

Unfortunately, scientists have been in the short term, and things have not gotten better, in the sense of returning to the old boom days, for more than a decade. It has taken us long-sighted, future-oriented scientists a long time to realize the facts and to begin to face up to their implications.

Mr. **Shamansky**. Do you think they have begun to do that now?

Dr. **Langenberg**. I do think they have begun.

Mr. **Shamansky**. My next question then is—does a grantee of money for instrumentation have a system for a depreciation schedule with a sinking fund? In other words, as part of the cost of a contract, do they set aside money to replace their instrumentation? Is that customary in science, or is it not?

Dr. **Langenberg**. No, it is not.

Mr. **Shamansky**. Has any thought been given to that?

Dr. **Langenberg**. A good deal of thought has been given to that. For example, the provision of such an element within the indirect cost recovery pool has been suggested but has not been viewed with sufficient favor by all concerned.

Mr. **Shamansky**. Is it because they will just say everything is an operating cost?

Dr. **Langenberg**. The general philosophy, as I understand it, of the Federal Government has been that if something is needed you purchase it up front.

Mr. **Shamansky**. But we have gotten to the point where that obviously has not worked, for the reasons just described by you.

Dr. **Langenberg**. You are correct.

Mr. **Shamansky**. I guess with a business law background I would suggest maybe we ought to try something else, and there is a precedent for it. Otherwise you are just going to be constantly coming back and being caught by surprise.

Dr. **Langenberg**. I would certainly agree that thinking about ways to do business in ways other than those that we have been using and that have gotten us into this fix could be useful.

Mr. **Shamansky**. Can you tell me if the National Science Foundation has approached or encouraged a national policy approach to the question of instrumentation? What I think I see is sort of an ad hoc thing. You know, you put the fire out here, then you do there, and so on.

When Sputnik went up, then the whole country was suddenly organized to address itself to that. Ohio State is still using the instruments it got then, and, as you say, they have been making do with them ever since.

In my own experience at least, I cannot remember the whole scientific establishment coming together and saying to the country, "This is what the problem is. We must commit ourselves to a program." Otherwise, your $95 million sort of sprinkled around in your budget to take care of a little bit is not going to do it. That is not a national approach to what I think is a national problem.

I think we are talking about big enough numbers. You are talking about $2-4 billion. Given the fact that deficits are back in style again, I suggest that maybe we get a couple more billion dollars back, because they are not important any more, and then we would really address the problem. As long as we have that margin in there given the size of the overall economy, at least we would be doing something about the future, and maybe then National Computer or whoever it is would not have to be buying technology from Hitachi.

I just think that maybe we ought to take sort of a big picture approach. I would like to think that the National Science Foundation or its Advisory Board could play that role.

Thank you, Mr. Chairman.

Mr. **Dymally**. Thank you.

Mr. Skeen?

Mr. **Skeen**. Thank you, Mr. Chairman.

I do not know whether deficits are back in style, but deficit thinking and those who profess to have answered all those questions are happy to see the possibility that we have not found all the answers as quickly as we thought we might—whatever justification that is.

The thing I am really concerned about in this instrumentation question is this: We are talking about large expenditures of capital in a program which is, by its own momentum, a rapidly changing one. The rapid advancement of instrumentation these days has created an obsolescence, and a very short-term one.

If I were you—and I am sure you have probably thought about this as much as anyone—I would be very reluctant to lay aside large sums of money for grants in the instrumentation field. How we get around this problem should be of far more concern than just how much money you are going to put in instrumentation. How do you keep it from becoming a program of investing in obsolescence? A situation has occurred, for example, in the electronics field. I wonder if the National Science Foundation has any recommendations to make in that particular area of concern.

Dr. LANGENBERG. Certainly one should not think of this problem as one that a large amount of money can solve once and for all. That $2 billion that I mentioned is a reasonable estimate of the magnitude of the catch-up problem. The maintenance problem is something else again. There too, we have fallen a little bit behind the kind of continuing investment in instrumentation that we need simply to stay even. In part that is why we are in the trouble we are in. But those two aspects of the problem can be separated.

The problem of maintaining capability is an equally important part of the problem. If overnight, by tomorrow morning, we were to catch up, we would still have the problem of keeping current and maintaining.

Mr. SKEEN. And that is the attitude, I think, that the National Science Foundation will take: How do we keep ourselves at a certain level of instrumentation? Thank you very much, Dr. Slaughter and Dr. Langenberg.

Mr. DYMALLY. Mr. Skeen, I was not quite clear: Is New Mexico for or against deficit spending?

Mr. SKEEN. Well, we are very much opposed to it, Mr. Chairman, since you ask the question. By Constitution, we cannot deficit spend. So, as a result of that, we have a large surplus. We might recommend the same thinking at the national level. [Laughter.]

Mr. SHAMANSKY. Mr. Chairman, I would like to point out that Ohio also has a requirement, and we are just $1 billion off after one of our greatest tax increases, with a Republican Governor, I am happy to say. So there are a lot of factors, Mr. Skeen. [Laughter.]

[Discussion off the record.]

Mr. DYMALLY. Dr. Slaughter?

Dr. SLAUGHTER. Mr. Chairman, should I proceed on the minorities and women activities, and we will answer questions on those issues?

Mr. DYMALLY. Yes. Please go ahead.

Dr. SLAUGHTER. There are a number of reasons that we need to be concerned about the status of women, minorities, and handicapped in science and technology. Everyone here would agree this country is experiencing a crucial time; it is suffering in the world marketplace; the economy needs strengthening; productivity and industrial organization are being questioned.

Part of the difficulty can be traced to the problem of fully involving—as Mr. Walgren said in his opening comment—the best talents. We must involve all of the intelligence that we can in addressing some of the critical problems facing the country. The problems of urban decay, of water and air pollution, of transportation require us to determine ways in which we can fully introduce into the work force persons with broad backgrounds, experiences, and training.

The rationale for attempting to improve the participation of women, minorities, and handicapped in science and technology cannot be merely to redress past grievances. It cannot be strictly to avoid national embarrassment of the kind traced as far back as John Gunther's work on the American dilemma. -The most important rationale is simply that the Nation suffers because women and minorities are not fully involved in what we are trying to accomplish.

Look at the science and engineering work force throughout the country; less than 10 percent are women, even though women make up a much larger share of the total professional work force. Twenty-two percent of the population of this country is composed of racial minorities, but only 4 percent of the persons involved in science and engineering are minorities.

Looking at what the engineering schools are doing now, one can take a great deal of satisfaction from the significant number of young women who are matriculating there. In some cases, 30 or 40 percent of the enrollments of the finer schools are young women pursuing careers in the engineering disciplines, a tremendous increase over the enrollments of 10 or 15 years ago.

The number of minority students graduating from the engineering schools has doubled, yet no more than 2 percent of the graduates are black, Chicano, or Native American. We have a great distance to go.

The National Science Foundation, with the help of the Congress, has recognized the importance of taking aggressive steps for greater participation by women, minorities, and handicapped. In 1981 the Science and Technology Equal Opportunities Act passed by the Congress was aimed at "promoting the full use of human resources in science and technology, insuring full development and use of scientific talent and technical skills of men and women equally, of all ethnic, racial, and economic backgrounds."

The Congress also authorized the Foundation to move ahead by establishing a Committee on Equal Opportunities in Science and Technology. That Committee is in place. At least one of its members, Dr. Sheila Pfafflin, is here today and will be speaking later with the subcommittee.

The subcommittee has assisted us in preparing reports forwarded to the Congress, including a recent report called "Proposals of the National Science Foundation To Promote the Fuller Participation of Minorities and Women in Science And Engineering."

NSF also has been looking at high-leverage opportunities for contributing to increased research and career opportunities for women and minorities in science and technology. Let me mention a few of them.

The minority research initiation program is being increased in the fiscal year 1983 budget by 47 percent, to a total of $2.5 million. The program supports young minority researchers who want to begin a research career and who need an opportunity to break into the competitive arena of proposing and receiving grants for scientific research. In fiscal year 1981, NSF made 19 awards at an average of $74,000 each. In fiscal year 1982, we expect to make 20 more awards at an average of $85,000 each. We are pleased with the results and the science emanating from these research awards. We believe they are a worthwhile investment of NSF research expenditures.

The research improvement and minority institutions program was begun in fiscal year 1982, in direct response to the President's Executive order for aggressive agency actions in support of the historically black colleges and universities. NSF's program takes in more than the historically black colleges and universities, but certainly they make up a significant share of the program's activities. In fiscal year 1983, the program will amount to $2 million. It is primarily concerned with providing improvements to institutions so that they can have stronger science and engineering facilities and faculties, and can participate more competitively in research activities. The program is being quadrupled in fiscal year 1983; we are pleased it is moving ahead.

I mentioned to you last week that plans for reorganizing the Department of Education call for transfer to the National Science Foundation of the minority institutions science improvement project. The program level is $3.3 million; it is primarily concerned with strengthening science education at the 2- and 4-year undergraduate institutions where enrollments are at least 50 percent black, Chicano, Native American, or Puerto Rican.

NSF graduate fellowships in fiscal year 1983 will include 50 new and 90 continuing fellowships for minority students. Of the $15 million allocated for graduate fellowships, $15 million are identified for minority graduate students.

In fiscal year 1982; we have begun a visiting professorship program for women; it will be doubled in fiscal year 1983 to $1 million. Its purpose is to increase the number of women who are active in research careers, to assist their mobility to other research universities, to become role models, to involve other women in science and engineering careers, and to increase the visibility and opportunities for career advancement.

We believe all these programs are important, Mr. Chairman; they are the kinds of programs that can go a long way toward improving opportunities for women and minorities in science and technology.

Let me say something now about NSF programs for research to aid the physically handicapped. Since 1977, NSF has had a program in the science and engineering education directorate concerned with increasing the opportunities for participation by the physically handicapped in scientific careers.

The physically handicapped, as much as women and minorities, suffer from prejudices and stereotypes that limit their opportunities for participating in careers in science and engineering. We believe NSF's program has helped to overcome at least part of those barriers. As we said last week, the program was reduced during the past 2 fiscal years. We have, however, seen an opportunity to contribute in other ways for encouraging scientific and technological research into improved capabilities of the physically handicapped.

We started in 1979 a program in the engineering activities. It has since become a part of the engineering directorate concerned with research on prosthetic devices, equipment to assist the deaf and the blind, so that they, too, can participate meaningfully in science and technology.

These programs are being integrated into various parts of the National Science Foundation. A number of individual projects have successfully competed and have been awarded for support of research addressing important areas to aid the physically handicapped.

Mr. Chairman, we are proud of the Foundation's activities in assisting greater participation by women, minorities, and handicapped in science and technology. There is always much more to be done. NSF resources are limited, and by no means do we feel NSF has the resources to do all that is necessary. We are trying to play a lead role, interacting with other Federal agencies, attempting to identify their responsibilities for support of these important activities.

We would be pleased now to answer any questions that you might have.

Mr. **Dymally**. Thank you very much.

Mr. Shamansky?

Mr. **Shamansky**. Thank you, Mr. Chairman.

Dr. Slaughter, you started out in your prepared testimony by saying that you are presenting the administration's request for funding fiscal year 1983. This is not in the way of a question; I am just going to make an observation that, at least in my opinion, it would not advance the cause of black participation in science and engineering to grant tax-exempt status to Bob Jones University.

I think that the administration might consider that, among other things in this area, because clearly we need as a country greater participation by minorities, women, and the handicapped in these programs.

Thank you, Mr. Chairman.

Mr. **Dymally**. Mr. Skeen?

Mr. **Skeen**. Thank you, Mr. Chairman.

Dr. Slaughter, I have a particular interest in the grants that have been made by the National Science Foundation to technical universities and junior colleges. We have one in my part of New Mexico.

We have the Navajo Junior College that received probably the greatest share of National Science Foundation funds of all our institutions of higher learning. I am curious as to what criteria those allocations were made, compared to, say, the University of New Mexico. I know it is parochial, but did the minority aspect of it have much to do with that kind of allocation?

Dr. **Slaughter**. That is a good question, Mr. Skeen. Yes, certainly, NSF recognizes that a serious problem has existed, particularly for improving the access of Native Americans to science and technology.

We are most proud of—and I should have mentioned it in my opening comment—the support NSF has provided to the Resource Center for Science and Engineering at the University of New Mexico and New Mexico State. The universities jointly proposed and are supporting the center. The success that the two universities have shown, with some support from the National Science Foundation, in taking leadership and involving Native Americans in science and technology is not only commendable, it is exemplary and should be examined by a number of other States for ways in which greater attention can be given to the particular needs of Native Americans. We are pleased to see the State of New Mexico and the presidents of the two universities take such serious interest in these needs.

Mr. SKEEN. Thank you.

Mr. DYMALLY. Thank you very much.

Dr. Slaughter, you stated there was an increase in funding for minorities and women, but when taken in a larger context they decrease.

In your briefing to the subcommittee, you start off in 1981 with $9 million. Funding for this research decreased $1.4 million last year. This year it went up, but what you have is a net decrease from 1981—an increase from 1982 but a decrease from 1981. This is our extract from your information.

Dr. SLAUGHTER. Mr. Chairman, I am not in a position to discuss every nuance of the funding. It may be that actual reductions can be found. I can say, however, that the changes from fiscal year 1982 to fiscal year 1983 are in the right direction, that the programs are much better focused, and NSF has a much better chance of making the contributions sought when Congress passed the Science and Technology Act and authorized the Committee on Equal Opportunity in Science and Technology. Those dollars will provide much higher leverage, perhaps, than some of the others; there will be a broader base upon which we can build for future requests.

Mr. DYMALLY. Mr. Skeen shared part of this concern earlier. I wanted to extend it just a little more. In talking about minority institutions, easterners have a perception that minorities are all blacks and very often neglect the Asian, Hispanic, and Indian population in the Southwest and West. What assurances do we have that some of the emerging Indian and Hispanic institutions are involved in minority institutions?

By the way, this eastern bias also includes blacks. The black bureaucrats think the same way; they have the same bias about westerners. [Laughter.]

Dr. SLAUGHTER. I lived for a time in the West, so my tendencies may have been smoothed by the opportunity to rub elbows with you out there.

The best assurance, Mr. Chairman, that our interests extend beyond black Americans is the existence of four resource centers in science and engineering. We are proud of all of them. One is in Puerto Rico, one in New Mexico, one in New York City, and one in Atlanta.

Mr. DYMALLY. I did not hear you say Ohio or California, so you are in trouble.

Mr. SHAMANSKY. Gross omissions, I might say. [Laughter.]

Dr. SLAUGHTER. I recognized the danger of identifying the locations as soon as I said them.

But NSF does work closely with the Chicano community in southern California—the MESA program with which you are familiar. There is no question that NSF's plans carefully consider the needs and skills of both the Native American and Chicano communities.

Mr. **Dymally**. In your testimony you gave the impression that you are moving very aggressively to assist minorities who are now in the system, now in college. What about the future?

Dr. **Slaughter**. That is where the resource centers come in, Mr. Chairman. The resource centers cover the spectrum—all the way from precollege to graduate research programs.

If any of you are near a resource center at any time, let me invite you to participate in a program known as the Saturday Academy. But stand a way from the door to prevent being trampled by excited young people who want to learn about science on Saturday mornings. They are often accompanied by parents equally enthusiastic about what their children are learning and creating.

We believe the program, if it becomes institutionalized, can have a wider impact than minority concerns. It represents an opportunity for young people to become excited by science and to learn that science is an inspirational and creative experience.

If NSF can continue to support such programs—and we intend to—they will represent an important part of the total effort and a role of leadership for the Foundation.

Mr. **Dymally**. I do not need to tell you how concerned the handicapped are about the proposal to eliminate their program because, as you stated, it was experimental. They had hoped that, instead of making it an experimental program, it would have been a permanent program in NSF. They have expressed their concerns to this subcommittee. Would you like to respond to that?

Dr. **Slaughter**. NSF is making a strong effort to insure that the research activities I mentioned for handicapped persons will be continued and can be strengthened.

It is true that the program concerned primarily with science education for the handicapped was a part of the network of programs reduced during the administration's budget review. I have no specific defense for the action other than to say it was a part of the large reduction in the total National Science Foundation budget for science and engineering education.

Dr. **Langenberg**. Mr. Chairman, if I might underline a point that Dr. Slaughter made with respect to research in areas of benefit to the handicapped, it should not be misunderstood that NSF is ceasing to support research in those areas; it is not.

We expect that proposals will come in, and we expect that some of those proposals will be supported in a wide variety of areas ranging through all the disciplines of engineering and material science. What is being phased out is the specific, labeled program.

Mr. **Dymally**. I know that you did not make a determination in all of these items, but in your program for minority institutions' science development program we seem to observe a decline, and yet you admit at the same time there is a problem with minority students. How do you reconcile your interests in this area yet your decline in emphasis?

Dr. **Slaughter**. I am not certain I accept the premise that there is a decline in emphasis.

Mr. **Dymally**. Not you, but a budgetary decline really.

Dr. **Slaughter**. I know you mean in budget terms. Do you mean from fiscal year 1981 to fiscal year 1983? Part of those programs was included in the science and engineering education budget, a relatively small percentage of the Foundation's activities.

But in terms of people investing their energies and thoughts to improving NSF programs oriented toward minorities and women and in terms of the potential for funding, there is an increase in NSF activity. The new RIMI program and the MRI program, for example, are funded at levels viable for both the concerns about individuals and the concerns about institutions.

We need to make those programs work well, we need to expand the number of participants in each program, and I am convinced there is a widespread commitment at the Foundation to do so; the budgets will follow when needed.

Mr. DYMALLY. Dr. Slaughter, this subject is of great interest to Mrs. Heckler. She is on her way. Could you stand by for just a few minutes?

Dr. SLAUGHTER. Certainly.

Mr. DYMALLY. If she does not come back, then we will have the consultant ask you some questions. Thank you very much.

If she comes back—I want to warn the witnesses—I will have Dr. Slaughter come back so Mrs. Heckler can ask some questions, and then we will go back to the regular schedule.

[The prepared statements of Dr. Slaughter, Dr. Langenberg, and Dr. Lewis M. Branscomb follow:]

STATEMENT OF
DR. JOHN B. SLAUGHTER
DIRECTOR, NATIONAL SCIENCE FOUNDATION

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
MARCH 4, 1982

I AM PLEASED TO BE HERE AGAIN THIS MORNING TO COMPLETE OUR PRESENTATION OF THE ADMINISTRATION'S REQUEST FOR THE FY 1983 NSF BUDGET. LAST WEEK I HAD THE OPPORTUNITY TO PRESENT AN OVERVIEW OF THE FOUNDATION'S REQUEST AND TO DESCRIBE THE PROCESS WE HAVE USED TO DEVELOP IT AND TO ASSESS OUR PROGRAMS AND PRIORITIES. LAST WEEK, DR. BRANSCOMB, CHAIRMAN OF THE NATIONAL SCIENCE BOARD WAS ALSO WITH ME AND DESCRIBED THE ROLE OF THE BOARD IN THE PREPARATION OF THE BUDGET, IN GENERAL, AND THE REVIEW OF SCIENCE AND ENGINEERING EDUCATION IN PARTICULAR.

DR. BRANSCOMB COULD NOT BE WITH US THIS MORNING. I HAVE A STATEMENT OF HIS ON THE IMPORTANCE OF GOVERNMENT POLICIES THAT CAN ENCOURAGE THE PRIVATE SECTOR TO PARTICIPATE MORE EFFECTIVELY IN UPGRADING SCIENTIFIC EQUIPMENT IN THE UNIVERSITIES WHICH I WOULD LIKE TO SUBMIT FOR THE RECORD.

Dr. Langenberg is with me again this morning and I have asked him to discuss the Foundation's activities and plans for supporting research instrumentation and facilities in academic institutions. He has been serving as Chairman of the Interagency Working Group on University Research Instrumentation which he will describe in more detail.

After he has finished his remarks, we will be pleased to answer any questions you or the Committee members may have about instrumentation needs before I make some concluding remarks on Foundation activities in the proposed FY 1983 budget regarding Women and Minorities in Science and Engineering Research Careers and Activities related to the physically handicapped.

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Continuation of Remarks

Women and Minorities in Science

The relative lack of participation by women and ethnic minorities in science and technology weakens national capabilities in industrial output, productivity growth and defense. In addition, shortages of highly skilled personnel in particular areas of science and technology -- computer science, parts of engineering, the earth sciences, for example -- are undoubtedly exacerbated by this situation. The valuable talents of minorities and women must be developed and employed in addressing these national needs.

In 1981, the Congress recognized the importance of strengthening our human resource pool in science and engineering when it passed the Science and Technology Equal Opportunities Act. This act states "...that it is in the national interest to promote the full use of human resources in science and technology and to insure the full development and use of scientific talent and technical skills of men and women, equally, of all ethnic, racial and economic backgrounds." The Congress also authorized the establishment of the Director's Committee on Equal Opportunities in Science and Technology. This Committee provided input for the Report recently submitted to this Committee on "Proposals of the NSF to Promote the Full Participation of Minorities and Women in Science and Engineering."

As I mentioned in my testimony last week on the overall structure of the Foundation's budget request for FY 1983, one of the guidelines we followed in assessing our programs and priorities was that of identifying high leverage opportunities for increasing research career opportunities for women and minorities. Several such opportunities are presented in the Administration's request.

Support of the Minority Research Initiation program will be increased by 47 percent to a total of $2.5 million over the FY 1982 Current Plan of $1.7 million. In FY 1981, the first year of its operation, this program made 19 awards averaging about $74.0 thousand to minority faculty members in a wide variety of institutions to assist them in initiating their research careers. It is

ESTIMATED THAT AN ADDITIONAL 20 AWARDS WILL BE MADE IN FY 1982 AT AN AVERAGE OF $85.0 THOUSAND. WE ARE PLEASED WITH THE POSITIVE RESPONSE TO THIS PROGRAM.

THE RESEARCH IMPROVEMENT IN MINORITY INSTITUTIONS (RIMI) PROGRAM WAS INITIATED IN FY 1982 IN RESPONSE TO THE PRESIDENT'S EXECUTIVE ORDER 12320 WHICH DIRECTS AGENCIES TO INCREASE THE PARTICIPATION OF HISTORICALLY BLACK COLLEGES AND UNIVERSITIES IN FEDERALLY FUNDED PROGRAMS. IN FY 1983, IT IS PROPOSED TO QUADRUPLE SUPPORT OF THIS PROGRAM TO A TOTAL OF $2.0 MILLION. AWARDS OF VARYING AMOUNTS GO DIRECTLY TO PREDOMINANTLY MINORITY INSTITUTIONS WITH GRADUATE SCIENCE AND ENGINEERING PROGRAMS TO HELP STRENGTHEN THEM, STIMULATE FACULTY RESEARCH, AND ENCOURAGE ACTIVITIES SUCH AS INDUSTRY/UNIVERSITY/COOPERATIVE RESEARCH AND INTER-UNIVERSITY COOPERATIVE RESEARCH AND SHARING OF RESEARCH FACILITIES AND INSTRUMENTATION.

THE MINORITY INSTITUTIONS SCIENCE IMPROVEMENT PROGRAM (MISIP) ACTIVITY IS PROPOSED FOR TRANSFER FROM THE DEPARTMENT OF EDUCATION IN FY 1983. THIS WOULD PROVIDE THE FOUNDATION WITH STILL ANOTHER OPPORTUNITY TO ASSIST IN BROADENING THE NATION'S PERSONNEL RESOURCE BASE IN SCIENCE AND ENGINEERING. THIS PROGRAM IS AIMED AT STRENGTHENING SCIENCE PROGRAMS IN 2-YEAR AND 4-YEAR UNDERGRADUATE INSTITUTIONS WHERE ENROLLMENTS ARE PREDOMINANTLY (MORE THAN 50 PERCENT) ALASKAN NATIVE, AMERICAN INDIAN, BLACK, MEXICAN AMERICAN, PUERTO RICAN OR OTHER DISADVANTAGED ETHNIC MINORITY. THE PROPOSED

FY 1983 BUDGET OF $3.3 MILLION WILL GIVE EMPHASIS TO CONSORTIUM-COOPERATIVE PROJECTS AMONG INSTITUTIONS AND TO ENHANCING OPPORTUNITIES FOR MINORITY PRE-COLLEGE STUDENTS TO INTERACT WITH PRACTICING SCIENTISTS AND ENGINEERS.

THE REQUEST FOR NSF GRADUATE FELLOWSHIPS IN FY 1983 INCLUDES PROVISION FOR 50 NEW AND 90 CONTINUING FELLOWSHIPS FOR MINORITY STUDENTS. FINALLY, SUPPORT FOR THE VISITING PROFESSORSHIPS FOR WOMEN PROGRAM, INITIATED IN FY 1982, WILL BE DOUBLED, FOR A TOTAL OF $1.0 MILLION IN FY 1983.

THIS PROGRAM IS INTENDED TO ENCOURAGE RESEARCH CAREERS FOR WOMEN AND TO PROVIDE GREATER VISIBILITY FOR WOMEN SCIENTISTS AND ENGINEERS EMPLOYED IN INDUSTRY, GOVERNMENT OR ACADEMIA. THE ELIGIBILITY REQUIREMENTS ARE BROADLY DRAWN. THE PROGRAM IS OPEN TO WOMEN WHO HOLD THE DOCTORATE DEGREE, OR WHO HAVE COMPARABLE EXPERIENCE, IN ANY FIELD OF SCIENCE OR ENGINEERING CURRENTLY SUPPORTED BY NSF, AND, WHO HAVE INDEPENDENT RESEARCH EXPERIENCE IN THE ACADEMIC OR PUBLIC SECTORS.

WE BELIEVE THAT ALL OF THESE PROGRAMS, DEVELOPED AS PART OF OUR CAREFUL ASSESSMENT OF NSF PRIORITIES WITHIN A CONSTRAINED BUDGET, COUPLED WITH THE ACTIONS WHICH WE OUTLINED FOR YOU IN OUR RECENT REPORT, PROVIDE THE FOUNDATION WITH HIGH LEVERAGE OPPORTUNITIES TO PARTICIPATE, WITH OTHER INSTITUTIONS, IN EXPANDING RESEARCH CAREER OPPORTUNITIES FOR MINORITIES AND WOMEN IN SCIENCE

AND ENGINEERING. OUR ROLE HERE IS A CATALYTIC ROLE. BUT WE WILL WORK CLOSELY WITH OTHER FEDERAL AGENCIES, PRIVATE INDUSTRY, PROFESSIONAL AND SCIENTIFIC SOCIETIES AND ACADEMIC INSTITUTIONS AND ENCOURAGE THEM TO JOIN US IN EXPANDING THE PARTICIPATION OF WOMEN AND MINORITIES IN SCIENCE AND ENGINEERING RESEARCH CAREERS.

PHYSICALLY HANDICAPPED

SINCE 1977, THE FOUNDATION HAS CONDUCTED A PROGRAM IN ITS SCIENCE AND ENGINEERING EDUCATION ACTIVITY TO INCREASE THE PARTICIPATION OF PHYSICALLY HANDICAPPED INDIVIDUALS IN SCIENTIFIC STUDY. IT WAS LEVEL FUNDED AT $500,000 PER FISCAL YEAR.

THIS WAS ONE OF THE MANY SMALL, FRAGMENTED PROGRAMS IN SCIENCE AND ENGINEERING EDUCATION WHICH WAS TERMINATED IN THE REVISED FY 1982 BUDGET SUBMITTED TO THE CONGRESS LAST MARCH AS PART OF THE PRESIDENT'S GENERAL PROGRAM TO REDUCE THE RATE OF GROWTH IN THE FEDERAL BUDGET AND TO CONCENTRATE FOUNDATION RESOURCES ON THE HIGHEST PRIORITY RESEARCH OPPORTUNITIES. WHILE IT MAY HAVE BEEN EFFECTIVE, TAKEN BY ITSELF, IT IS ONE OF THE MANY ACTIVITIES IN EDUCATION WHICH WE HAVE PHASED OUT WHILE WE SEEK A CONSENSUS ON THE NEW DIRECTIONS AND POSSIBLE ROLES FOR THE FOUNDATION IN SCIENCE AND ENGINEERING EDUCATION IN THE 1980'S.

At the request of the Congress in FY 1979, we also established a small applied research program directly focused on encouraging scientific and technological research concerning the handicapped. We viewed this activity as an experimental effort to complement the significantly larger research programs of the National Institute of Handicapped Research (NIHR) and other agencies.

As this Committee is aware, in FY 1981 we established an Engineering activity for supporting fundamental research in engineering. The Foundation gave such research high priority in its plans, a priority which is continued in the FY 1983 request.

Given the limited resources available to support this fundamental engineering research and the priority attached to it by myself and the National Science Board, we felt that applied proposals for work related to the physically handicapped should compete directly for support with other proposals in engineering. Such a step is in keeping with our more general reorganization of applied research in the spring of 1981.

We have phased out the targeted program in FY 1983 and made these applied research proposals eligible to compete for funds across all engineering programs. This really broadens the possible base of support for them while assuring that our funds are used to support the best engineering research proposals. I am certain that you will be pleased to to know that several such proposals have already been funded as continuations or new starts in one or another of our engineering programs.

CONCLUDING REMARKS

I WOULD LIKE TO CONCLUDE OUR REMARKS, TODAY, BY REITERATING SEVERAL POINTS WHICH I MADE IN MY OPENING STATEMENT LAST WEEK.

WE BELIEVE THAT THE ADMINISTRATION'S BUDGET REQUEST FOR FY 1983 FOR THE FOUNDATION IS A SOUND, STRONG ONE THAT WILL GIVE US THE MAXIMUM RETURN FOR THE DOLLARS REQUESTED. IT IS THE RESULT OF A CAREFUL ASSESSMENT OF PRIORITIES AND NEEDS, BY A VARIETY OF GROUPS. WE BELIEVE IT REPRESENTS A CONSENSUS ON THE IMPORTANCE OF RESEARCH AND ON THE NEED FOR THE FOUNDATION TO PLAY A KEY ROLE IN MAINTAINING THE STRENGTH OF THE NATION'S BASIC KNOWLEDGE BASE.

IT HAS SOMETIMES SEEMED TO ME THAT WE HAVE FOCUSED ON A LIMITED NUMBER OF AREAS -- SCIENCE AND ENGINEERING EDUCATION, RESEARCH RELATED TO THE PHYSICALLY HANDICAPPED, SCIENTIFIC INSTRUMENTATION, PROGRAMS FOR WOMEN AND MINORITIES --WITHOUT CONSIDERING THEM IN THE CONTEXT OF THE FOUNDATION'S RESPONSIBILITIES AND AVAILABLE RESOURCES AS A WHOLE.

I HOPE THAT MY REMARKS AND THOSE OF DR. BRANSCOMB AND DR. LANGENBERG HAVE HELPED TO PLACE THE TOPICS OF SPECIFIC INTEREST TO YOU AND OTHER COMMITTEE MEMBERS IN THE BROADER CONTEXT OF THE JUDGMENTS WE HAVE MADE IN PREPARING OUR BUDGET REQUEST TO THE CONGRESS. IT IS THIS BROADER CONTEXT WHICH HELP MAKE UNDERSTANDABLE THE SPECIFIC CHOICES WE HAVE MADE.

THANK YOU.

STATEMENT OF
DR. DONALD N. LANGENBERG
DEPUTY DIRECTOR, NATIONAL SCIENCE FOUNDATION

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
MARCH 4, 1982

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE,

AS DR. SLAUGHTER MENTIONED IN HIS TESTIMONY LAST WEEK, WHILE ASSESSING OUR PRIORITIES AND NEEDS IN THE PREPARATION OF THE FY 1983 BUDGET REQUEST, WE TOOK A CLOSE LOOK AT RESEARCH INSTRUMENTATION AND FACILITIES NEEDS RELATIVE TO OTHER RESEARCH OPPORTUNITIES.

AS THE MEMBERS OF THIS COMMITTEE KNOW, OVER THE LAST FEW YEARS THE FOUNDATION HAS PLACED A VERY HIGH PRIORITY ON UPGRADING THE SCIENTIFIC AND ENGINEERING INSTRUMENTATION AVAILABLE IN THE NATION'S COLLEGES AND UNIVERSITIES FOR CONDUCTING FOREFRONT RESEARCH IN A VARIETY OF DISCIPLINES. THIS YEAR IS NO EXCEPTION. I WOULD LIKE TO TAKE A FEW MOMENTS TO CHARACTERIZE THE GENERAL NATURE OF THE PROBLEM AND DESCRIBE FOR YOU WHAT THE ADMINISTRATION IS PROPOSING IN THE FOUNDATION'S FY 1983 BUDGET.

THERE IS AN EMERGING CONSENSUS IN UNIVERSITIES, THE FEDERAL GOVERNMENT AND PRIVATE INDUSTRY THAT THERE IS A CRITICAL AND GROWING NEED TO REPLACE OBSOLETE AND WORN-OUT RESEARCH APPARATUS AND LABORATORY FACILITIES IN THE NATION'S RESEARCH UNIVERSITIES.

ALTHOUGH ITS PRECISE DIMENSIONS ARE NOT KNOWN, THERE IS STRONG, QUALITATIVE EVIDENCE THAT THE PROBLEM IS PERVASIVE AND LARGE IN SCOPE. A ROUGH, BUT REASONABLE, ESTIMATE OF THE LOWER LEVEL OF THE DEFICIT IS $1.0 BILLION. UPPER BOUNDARIES OF THE PROBLEM HAVE BEEN PLACED IN THE $3.0-$4.0 BILLION RANGE.

IF THE GENERAL ASSESSMENT OF THE SCOPE AND NATURE OF THE PROBLEM IS A CORRECT ONE, AND WE BELIEVE THAT IT IS, IT MEANS THAT THE PRODUCTIVITY AND EFFICIENCY OF THE NATION'S ACADEMIC RESEARCH ENTERPRISE HAS ALREADY DECLINED AND WILL CONTINUE TO DECLINE. MOST OF MODERN SCIENCE AND ENGINEERING RESEARCH IS INSTRUMENT-DEPENDENT. CAPITAL INVESTMENT IN ADVANCED INSTRUMENTATION AND FACILITIES IS NECESSARY IF WE ARE TO MAINTAIN OUR NATIONAL POSITION AT THE FOREFRONT OF A WIDE VARIETY OF DISCIPLINES AND TO OBTAIN MAXIMUM PRODUCTIVITY IN THE FUTURE FROM OUR INVESTMENT IN RESEARCH.

CURRENTLY, THE FOUNDATION IS EXPLORING THE DEVELOPMENT OF A SYSTEM OF INDICATORS ON THE STATUS OF UNIVERSITY RESEARCH LABORATORIES AND EQUIPMENT TO GIVE US A BETTER PICTURE OF THE SCOPE OF THE PROBLEM. PRELIMINARY DATA OBTAINED IN THE FALL OF 1981 IN A SAMPLE OF 38 INSTITUTIONS SUGGEST THAT ABOUT HALF OF ALL EQUIPMENT

HOLDINGS WERE ACQUIRED 6-10 YEARS AGO AND THAT SHARED USE OF INSTRUMENTS AMONG RESEARCHERS AND DEPARTMENTS IS VERY COMMON.

EVEN THOUGH CONSIDERABLE WORK REMAINS TO BE DONE TO DEVELOP BETTER QUANTITATIVE INFORMATION, SOME IMMEDIATE ACTION CAN BE TAKEN. I WOULD LIKE TO DISCUSS SEVERAL THINGS THAT HAVE BEEN DONE IN THE PAST YEAR, AND COMMENT ON HOW NSF'S CURRENT BUDGET REQUEST ADDRESSES THE SITUATION.

EFFORTS TO UPGRADE OUR RESEARCH "HARDWARE" ARE CLEARLY NECESSARY; YET, THE NATION FACES ECONOMIC PROBLEMS AND BUDGETARY CONSTRAINTS. ANY SOLUTION MUST ENCOMPASS NOT ONLY THE FOUNDATION, BUT OTHER FEDERAL AGENCIES, ACADEMIC INSTITUTIONS THEMSELVES, STATE GOVERNMENTS AND INDUSTRY.

LAST AUGUST, WITH THE SUPPORT OF THE DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, THE FOUNDATION CONVENED AN INTERAGENCY WORKING GROUP ON UNIVERSITY RESEARCH INSTRUMENTATION TO BEGIN REVIEWING THE NATURE AND EXTENT OF THE PROBLEM AND TO EXPLORE SEVERAL SCHEMES FOR A POSSIBLE FEDERAL RESPONSE TO IT. REPRESENTATIVES OUTSIDE NSF CAME FROM THE DEPARTMENT OF AGRICULTURE, DEPARTMENT OF DEFENSE, DEPARTMENT OF ENERGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, AND THE NATIONAL INSTITUTES OF HEALTH.

THE WORKING GROUP CONCLUDED THAT INADEQUATE UNIVERSITY RESEARCH INSTRUMENTATION WAS INDEED A PERVASIVE AND ENDEMIC PROBLEM, AND THAT THE NATION WOULD BENEFIT FROM ITS ALLEVIATION.

BECAUSE OF THE DIVERSITY OF MISSION RESPONSIBILITIES, AN APPROACH INVOLVING INTERAGENCY COORDINATION RATHER THAN A SINGLE INTEGRATED PROGRAM WAS THOUGHT TO BE PREFERABLE. SUCH A STRATEGY FACILITATES MATCHING INDIVIDUAL AGENCY PRIORITIES, ASSESSING THE RELATION TO OTHER RESEARCH REQUIRMENTS, AND ENABLING A BETTER RESPONSE TO SPECIAL NEEDS OF DIFFERENT SCIENTIFIC AREAS.

FOLLOWING THIS PLAN, IN FY 1983:

- THE DEPARTMENT OF DEFENSE IS PROPOSING A $30 MILLION INITIATIVE TO BUILD THE UNIVERSITY RESEARCH BASE FOR DISCIPLINES RELATED TO ITS SCIENTIFIC PROGRAMS;
- NASA IS HAVING ITS PROGRAM OFFICERS GIVE SPECIAL ATTENTION TO PROJECT-RELATED INSTRUMENTATION REQUESTS;
- NIH PLANS TO INCREASE ITS CURRENT INSTRUMENTATION PROGRAMS SLIGHTLY;
- THE DEPARTMENT OF ENERGY PLANS TO INSTRUCT ITS PROGRAM OFFICERS TO PROTECT BUDGETS FOR INSTRUMENTATION IN ITS RESEARCH AWARDS;
- NSF RESEARCH PROGRAMS ARE INCREASING THEIR SUPPORT FOR MAJOR EQUIPMENT AND OTHER INSTRUMENTATION BY 11.5 PERCENT OVER FY 1982 TO A TOTAL OF $95.3 MILLION; AND
- THE INTERAGENCY WORKING GROUP WILL CONTINUE TO MONITOR, COORDINATE AND HEIGHTEN AWARENESS OF THE PROBLEM.

WITHIN THE NSF TOTAL, EACH SCIENTIFIC AREA IN THE FOUNDATION IS RESPONDING TO THE NEEDS OF ITS DISCIPLINE. OVERALL INCREASES IN EQUIPMENT AND INSTRUMENTATION SUPPORT RELATIVE TO FY 1982 RANGE FROM 4.8 PERCENT FOR THE U.S. ANTARCTIC PROGRAM TO 23.5 PERCENT FOR ENGINEERING.

SOME PROGRAMS HAVE INCREASED THEIR SUPPORT TO INVESTIGATORS ON THEIR RESEARCH GRANTS; SOME ARE PROVIDING INSTRUMENTATION FOR SHARED USE; SOME PROVIDE RESEARCH INSTRUMENTATION AND FACILITIES THAT ARE TOO SPECIALIZED AND EXPENSIVE TO WARRANT DUPLICATION.

WITHIN THE MATHEMATICAL AND PHYSICAL SCIENCE ACTIVITY, FOR EXAMPLE, PREVIOUS EMPHASIS ON EXPERIMENTAL COMPUTER RESEARCH WILL CONTINUE THE MULTI-USER REGIONAL INSTRUMENTATION FACILITY.

THE PHYSICS PROGRAM WILL PROVIDE SUPPORT FOR CONSTRUCTING A COOLER RING AT THE INDIANA UNIVERSITY CYCLOTRON AND FOR IMPROVING THE DETECTOR AND STORAGE RING AT THE CORNELL ELECTRON STORAGE RING.

IN THE BIOLOGICAL, BEHAVIORAL AND SOCIAL SCIENCE ACTIVITY PARTICULAR ATTENTION IS BEING GIVEN TO UPGRADING INSTRUMENTATION AT MARINE BIOLOGICAL STATIONS, STRENGTHENING ARCHEOMETRIC DATING FACILITIES, AND IN GENERAL PROVIDING ADEQUATE INSTRUMENTATION IN RESEARCH PROJECT AWARDS.

THE ENGINEERING PROGRAM PLANS TO SUPPORT THE INITIAL PHASE OF A FLUIDIZED BED RESEARCH FACILITY.

AS PART OF THE THRUST IN EARTH SCIENCES, IN THE ASTRONOMICAL, ATMOSPHERIC, EARTH AND OCEAN SCIENCES ACTIVITY, SUPPORT OF EQUIPMENT IS BEING ENHANCED ON INDIVIDUAL GRANTS FOR GEOCHEMICAL AND GEOPHYSICAL RESEARCH.

FUNDING FOR RESEARCH INSTRUMENTATION FOR FACULTY AT TWO-AND FOUR-YEAR COLLEGES WILL CONTINUE IN FY 1983. THIS PROGRAM APPEARS TO HAVE BEEN EXTREMELY SUCCESSFUL IN SUPPORTING SMALL RESEARCH EQUIPMENT ACQUISITION AT THESE INSTITUTIONS, THUS UPGRADING SIGNIFICANTLY THE RESEARCH CAPABILITIES OF THEIR FACULTIES. INSTEAD OF PROVIDING A SEPARATELY IDENTIFIED BUDGET LINE FOR THE PROGRAM, SUPPORT WILL BE PROVIDED BY THE RELEVANT RESEARCH DIRECTORATES IN ORDER TO MAINTAIN A CLOSE COUPLING TO THE SCIENCE DISCIPLINES.

IN CONCLUSION, WHILE THE FOREGOING ACTIVITIES WILL CERTAINLY NOT ELIMINATE THE NEED FOR MAJOR RENOVATION OF ADVANCED SCIENTIFIC AND ENGINEERING INSTRUMENTATION THEY DO REPRESENT A REALISTIC AND MEANINGFUL APPROACH AT A TIME WHEN OVERALL ECONOMIC RECOVERY IS A MAJOR NATIONAL CONCERN. WHAT HAS BEEN DONE BY THE FOUNDATION IN FY 1982, AND IS PROPOSED FOR FY 1983, CALLS ATTENTION TO THE NEED FOR CONTINUING EFFORT IN THIS AREA; PROVIDES FOR A BALANCE ACROSS AREAS OF SCIENCE; MEETS THE MOST CRITICAL CURRENT RESEARCH NEEDS WITHIN A CONSTRAINED BUDGET, AND ALLOWS FOR THE EXPLORATION OF NEW WAYS OF PROVIDING THE INSTRUMENTATION ESSENTIAL TO FULL UTILIZATION OF THE NATION'S SCIENTIFIC AND ENGINEERING MANPOWER POOL, E.G., STIMULATING INDUSTRY TO CONSIDER DONATING INSTRUMENTATION TO A UNIVERSITY IN COORDINATION WITH THE AWARD OF AN NSF GRANT.

I WOULD BE PLEASED TO ANSWER ANY QUESTIONS THAT YOU MAY HAVE.

STATEMENT OF LEWIS M. BRANSCOMB
CHAIRMAN, NATIONAL SCIENCE BOARD
SUBMITTED TO THE
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES
MARCH 4, 1982

My name is Lewis M. Branscomb. I am Chairman of the National Science Board, and am submitting this statement in that capacity. I also am Vice President and Chief Scientist of the IBM Corporation.

Dr. Langenberg discussed the importance of the industrial sector. I want to make some general observations on research instrumentation, and will emphasize the importance of Government policies that can encourage the private sector to participate more effectively in upgrading scientific equipment in the universities.

But, first, I want to make a brief observation on the other question on today's agenda--the participation of women and minorities in scientific and engineering careers. The National Science Board places a very high value on excellence in science. All our experience shows that discoveries cannot be planned, that trying hard is not a substitute for talent, that natural ability, motivation, and opportunity are the recipe for scientific excellence. We equally firmly believe that natural ability in mathematics and science is distributed randomly throughout all elements of our population. Unhappily, some of our youth, especially young women and minorities, are often discouraged from pursuing scientific careers. And opportunity for those careers does not always follow ability and motivation alone.

The consequence of these facts is that the excellence of our science inevitably suffers if we fail to give every rare talent the opportunity to prove itself. Equal opportunity is not counter to a focus on excellence; it is indispensable to it. Thus, it is appropriate that all the programs of the Foundation be conducted with this fact in mind. Quite apart from the matter of fairness, our country simply does not have enough bright, scientifically inclined youngsters for us to afford to deprive a good education, high motivation, and career opportunity to any of our citizens.

Let me now turn to the question of instrumentation. This issue is more important than the contribution to research productivity that modern instrumentation can provide. The fact is that the tools of science and the tools of productivity are linked by the processes of discovery and innovation, each contributing to the other. Leading edge scientific instrumentation is an essential link in the evolution of new scientific ideas to exploitation of these ideas in the Nation's technology. The National Science Board addressed this point in our policy statement of March 1981, which noted that keeping university equipment at the cutting edge sparks both innovation and productivity improvements in American industry broadly.

Thus, the policy of the Board goes beyond balancing the Federal investment between facilities and talent for research. We seek to keep vital the roots of invention of new instrumentation for science, the rapid development of these ideas by priva companies, large and small, and the evolution of the researcher's tools into the design and production tools of industry.

To this end a close collaboration among our university and industrial laboratories is essential. The Economic Recovery Tax Act of 1981 contains two provisions intended to encourage industry to share its instrumentation and knowledge with universities to their mutual benefit.

First, Section 221 of the Act provides a 25 percent tax credit for incremental R&D expenses. The credit equals 25 percent of the amount by which qualified R&D expenses during a year exceed the average of the previous three years. Qualified R&D expenses for in-house research include the wages of researchers and direct support personnel, the cost of supplies, and payments for the lease of equipment. Thus overhead and capital costs are not eligible for the credit (although the company's capital equipment costs may qualify for the investment tax credit). Qualified research expenses for research contracted out are 65 percent of the contract cost, a percentage designed to approximate the ratio of wages, supplies, and leased equipment to the total research cost.

This provision could and should be used by private firms to collaborate with colleges and universities and improve their instrumentation. For example, if a firm sponsored a university research project involving the purchase of a centrifuge, the cost of the centrifuge would be fully deductible as a research expense to the firm. Furthermore, 65 percent of the centrifuge's cost would be included as "qualified research" and would count in computing the amount of incremental research eligible for the 25 percent credit to the firm. Thus, if the centrifuge were part of the firm's incremental research and the firm were in the 46 percent tax bracket, the firm would pay for only 38 cents out of each dollar of the cost of the acquisition of the centrifuge by the university. If the same research were conducted in-house at the same gross expense, the centrifuge would cost the company a net after tax cost of 54 cents out of each dollar, minus the tax benefits of depreciation.

Unfortunately, Section 221 has administrative and substantive ambiguities that may limit its value in encouraging firms to increase R&D expenditures, including those expenditures that improve instrumentation at universities. The Treasury is now drafting regulations to reduce uncertainty. The issuance of proposed regulations for Section 221 deserves and is receiving a high priority, and the proposed regulations should be published soon.

Section 222 can be even more valuable in encouraging firms to assist in updating equipment at colleges and universities. After the passage of Section 222, contributions of equipment to universities entitle the firm to a much larger tax deduction if certain conditions are met. For example, if a firm donates a new centrifuge that costs $100 to make and sells for over $300, the tax deduction would be only $100 under the old law but $200 under Section 222. Firms can be expected to significantly increase donations of scientific equipment to colleges and universities once they gain familiarity with the favorable provisions of the new law.

In order for a firm to receive the increased donation, the gift must be new equipment that is constructed by the firm and given without strings attached to an institution of higher education. The firm and the institution must have a written agreement that the equipment will be used in the U.S. for research in the "physical or biological sciences." These conditions also involve some uncertainties that must also be resolved by Treasury regulations. For example, the very term "physical or biological sciences" must be interpreted or extended to include mathematical and engineering sciences at a minimum. The issuance of regulations now being developed that reduce or eliminate uncertainty and guide firms in the proper use of Section 222 will be beneficial to American science and technology.

Many firms are studying ways to use these provisions to improve and update the scientific instrumentation used by our country's colleges and universities, but the extent of their effect is still unknown.

The Foundation should and will seek to encourage private companies to expand their participation in university research, and these provisions will surely help. But we cannot realistically expect the obsolescence problem described by Dr. Langenberg to be solved in this way. We must also encourage the universities to share expensive facilities, to avoid the temptation to underinvest in equipment as a fraction of project cost, and to find innovative ways to capitalize new equipment acquisition with non-Federal funds.

I am pleased to have had the opportunity to present these views.

Mr. Dymally. Let me introduce the second panel now: Dr. Pfafflin, Dr. Merideth, and Dr. Mann.

Dr. Pfafflin, you are the lead hitter. For the record, would you introduce yourself, please?

[The biographical sketch of Dr. Pfafflin follows:]

August 1981

SHEILA M. PFAFFLIN

EDUCATION

B.A., Pomona College, 1956; M.A., The Johns Hopkins University, 1958; Ph.D., The Johns Hopkins University, 1959; field, Psychology.

PROFESSIONAL EXPERIENCE

1959-1975, Member of the Technical Staff, Bell Laboratories, Murray Hill, N.J.; 1975-present, District Manager, Human Resources Department, American Telephone & Telegraph Company. Fields of professional specialization: human learning and training, statistics and experimental design, human resource research.

PROFESSIONAL ACTIVITIES

President, AWIS Educational Foundation, 1982; Fellow, AAAS, 1982; Member, National Science Foundation Committee on Equal Opportunity in Science and Technology, 1981; President, Association for Women in Science, 1980-81; Fellow, New York Academy of Sciences, 1980; Executive Council Member, FOPW, 1979-80; Vice President, New York Chapter, AWIS, 1978-79; Treasurer, Federation of Organizations for Professional Women, 1976-78; Vice President, AT&T Women's Alliance, 1976; Member, Committee for Women in Science of the New York Academy of Sciences, 1975-81; President, Women's Rights Association, 1974.

Other activities include: Organized workshop on the employment of technical and professional women in the utilities industries for the meeting on Upward Mobility for Women, organized by the Federation of Organizations for Professional Women, Nov. 5-7, 1976; member of the NGO Taskforce on the Roles of Women for the United Nations Conference on Science and Technology for Development, held in August, 1979; chair of Workshop on Women in Science at the United Nations Institute for Training and Research (UNITAR) seminar, "Creative Women in Changing Societies," Oslo, July 1980; organized symposium on "Women in Science and Technology: an International Perspective" for the NGO Forum, Copenhagen, July 1980.

TALKS AND PUBLICATIONS

Author of papers concerned with human learning and training, statistics, and human resource issues, including: "Special Employment Settings: Women in Industry," a paper presented as part of a symposium on employment issues for women in psychology, American Psychological Association Meeting, 1978; A. M. Briscoe and S. M. Pfafflin (eds), "Expanding the Role of Women in the Sciences," Annals of the New York Academy of Sciences, v. 323, 1979 (proceedings of the conference on this subject, sponsored jointly by the New York Academy of Sciences and the AWIS Educational Foundation, in 1978); "Recruiting Women in Science," presented at the Recruitment Workshop, Women at Work Exposition (Women's Action Alliance Meeting), 1979; "Some Reflections on Women in Science and Technology after UNCSTD" for UNITAR publication on UNCSTD (in press).

PRESENT ADDRESS

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STATEMENTS OF DR. SHEILA PFAFFLIN, DISTRICT MANAGER, HUMAN RESOURCES DEPARTMENT, AMERICAN TELEPHONE & TELEGRAPH CO.; DR. CHARLES W. MERIDETH, CHANCELLOR, ATLANTA UNIVERSITY CENTER; AND DR. ROBERT W. MANN, WHITAKER PROFESSOR OF BIOMEDICAL ENGINEERING, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dr. **PFAFFLIN**. Thank you, Mr. Dymally.

Mr. Chairman and members of the subcommittee, I am Sheila Pfafflin. I am president of the Association for Women in Science Educational Foundation and chair of the Subcommittee on Women of the National Science Foundation's Committee on Equal Opportunities in Science and Technology. I welcome this opportunity to testify on the actions needed to achieve the full participation of women in science and technology.

Today our country faces the serious problem of developing the human resources to meet the needs of our increasingly technological society.

A relatively constant proportion of the population has gone into science and technology. If we are going to increase our proportion of the work force in these areas while maintaining or improving quality, we must increase the sources available to us.

Women represent a major source of talent for this purpose which is largely untapped at present. I will not go into statistics, but for example, in 1980 out of 2,400 doctorates which were awarded in engineering, only 90 went to women.

It is a matter, therefore, of national interest in the efficient utilization of our human resources as well as in the achievement of equality of opportunity that the present barriers to the full participation of women in science be reduced.

Barriers facing women in science and technology are found in two major areas—education and employment. Of these, the barriers which women face to career advancement are the most serious.

Women cannot be expected to undertake the often long and demanding training required for a career in science and technology if they are to be denied the normal professional rewards. A recent study by the National Academy of Sciences has shown that women scientists are still denied equitable access to these rewards.

In this study a matched sample of men and women scientists were studied, and it showed a continuing pattern of differential rewards for men and women scientists which cannot be explained on the basis of differences in their backgrounds, education, professional experience, or life situations.

Women employed in universities and colleges, for example, are less likely to be in tenure-track positions, are less likely to be granted tenure, and receive lower pay for comparable qualifications and contributions. These trends are present for recent graduates as well as for those who have received their degrees in years past.

Progress has been made in some areas where enforcement of equal opportunity legislation and organizational commitment have been greatest, but in the colleges and universities where most women scientists are employed and where enforcement has been weak or absent, there has been less progress.

There has been much concern that recent Government policies may deter further progress and could result in the loss of gains which have already been made.

Equal opportunity in science and technology is a proper concern of this committee. It is a key to the effective utilization of our scientific human resources.

As Dr. Slaughter has made clear in his recent report to the Congress, there are many ways in which granting agencies can encourage the increased participation of minorities and women in science and engineering and work toward more equitable treatment for those who enter these fields through their regular programs.

Such efforts are especially significant for women, since programs which specifically address the needs of women in science and technology are rare.

In particular, efforts are needed to establish more equitable treatment of individuals, both men and women, who are not in tenure-track positions, both with regard to opportunities to apply for grants and with regard to treatment of personnel supported by grants.

Women are more likely to be in nontenure-track positions in universities, and many institutions do not let such individuals apply for grants. The granting agencies can have a substantial impact by providing incentives for change.

Programs for women reentering science and technology are also needed. The highly successful reentry programs have shown that they can be a very cost-effective way of rapidly increasing our supply of scientists and engineers. In as short a time as 1 year these programs retrain women to be engineers, computer scientists, and other needed specialists.

It has been estimated that the increased dollars in taxes paid by their graduates will more than repay the cost of these programs over the years. Their elimination from the 1982 and the 1983 NSF budgets would appear to be a classic example of a penny-wise, pound-foolish decision.

I would also like to comment in response to Mr. Dymally's question earlier that there has indeed been an absolute reduction in funding for women's programs; 1982 represents only 25 percent of 1981 funding, and 1983 will only be 50 percent.

While we are very grateful to have a new program, I cannot feel that the programs which were not funded were either badly focused or that the total amount involved is going to compensate for the loss.

The Subcommittee on Women was very pleased to see that money for the implementation of the visiting professorships program, which was authorized but never funded, has been included in the budget for 1982 and the proposed budget for 1983.

I would also strongly recommend that the national research opportunity grants, another program which was authorized but never implemented, be funded. Women scientists, far more often than men, remain in postdoctoral and research associate positions where they are unable to pursue independent research.

Providing research support for women who are starting careers in science or reentering science after a career break is a crucial step toward launching them on productive scientific careers.

Efforts are needed to promote research opportunities for women employed in colleges which do not have extensive research facilities. Funds for research at research-oriented institutions in nearby locations would be valuable in this regard, as would programs to reduce the heavy teaching load encountered by women in smaller colleges and universities.

Another serious problem for women scientists has been the selective pattern of the administration budget cuts in science support. Women scientists are most heavily represented in the social and behavioral sciences, the areas which have suffered the most severe budget cuts.

Moreover, research in the behavioral sciences, including such areas as how mathematics in science can be best taught and learned, is important to increasing the participation of women in science and technology. Such research will be severely affected by the budget cuts.

The cutbacks in Federal support for science education at NSF are also a serious concern. The excellent, highly cost effective science career workshops directed to women students are no longer being funded. These programs had impact far beyond their dollar value and led to many other innovations which would not have occurred without them.

Even apart from the impact on programs specifically devoted to women, the reduction in funding for science education programs has serious implications. Programs in science education which are now being developed in some other agencies are a highly questionable substitute, and some are being implemented in ways which may have the effect, if not the intent, of severely restricting the participation of women.

It would seem reasonable to expect that any program encouraged by the Federal Government in the area of science education should have women and minorities represented in proportion to their numbers in the target population. Steps should be taken to insure the unbiasing of these programs.

Another concern in the area of access to careers in science lies in the cutbacks in Federal support for students. Studies in the past indicate that, in addition to encountering barriers to admission, either through exclusion, quotas, or in being required to meet higher standards than males, women have suffered financial handicaps relative to males in their access to higher education.

The increased availability of Federal support for programs of financial assistance to college students helped to remedy this situation in the 1970's. However, this improvement is being swept away through the administration budget cuts.

The need to earn a larger share of college expenses will fall more heavily on women students, since they are seldom able to earn as much as male students. The alternative sources of funding being suggested appear, in many cases, to be less available to women, so that unless special efforts are made, many young women, from moderate income families will be effectively barred from pursuing careers in science and technology.

The special needs of particular groups of women must also be addressed. Minority women, handicapped women, and women from poor families continue to face serious access barriers to careers in science and technology. Cuts in support for science education are likely to have a serious negative impact on these groups.

Programs to increase the participation of women in science and technology have received very little funding, and minority women report that programs designed for minorities have sometimes neglected the concerns of minority women.

Here again there is evidence of the need for monitoring of all Federal programs to insure that women are represented in such programs in proportion to their numbers in the target population and that the content of such programs be designed to be equally appropriate for males and females.

In summary, congressional action is needed to achieve full utilization of women in science. The recommendations would include actions to have agencies which fund research make full use of the opportunities which exist within their present programs to encourage participation and to work toward equitable treatment of women in science and technology.

Funding should be provided for the reentry programs, for career science workshops, and for the national research opportunity grants, as well as being continued and increased for the visiting professorship program. We also need additional initiatives for mid-career women. Special attention does need to be addressed to the needs of minority women, the handicapped, and the economically disadvantaged women.

Finally, universities should be encouraged to eliminate barriers to women, such as prohibitions on applications for grants by people not in tenure-track positions, and efforts should be undertaken to insure that all federally supported programs in science education are designed to be equally appropriate for men and women and that the participation of women is equal to that of men.

Thank you.

[The prepared statement of Dr. Pfafflin follows:]

Statement of Sheila M. Pfafflin, President, Association for Women in Science Educational Foundation and Chair, Subcommittee on Women, Committee on Equal Opportunities in Science and Technology, National Science Foundation

Women in Science and Technology: An Underutilized Resource

Mr. Chairman, and members of the Subcommittee:

My name is Sheila M. Pfafflin, and I am President of the Association for Women in Science Educational Foundation and Chair of the Subcommittee on Women of the National Science Foundation's Committee on Equal Opportunities in Science and Technology. I welcome this opportunity to testify on the actions needed to achieve the full participation of women in science and technology.

Today our country faces the serious problem of developing the human resources to meet the needs of our increasingly technological society. The proportion of our population choosing careers in science and technology over the years has remained relatively constant. If we are to meet our requirements for trained technical personnel, we must develop additional resources. Women represent a major source of talent for this purpose, which is largely untapped at present. It is a matter, therefore, of national interest in the efficient utilization of our human resources as well as in the achievement of equality of opportunity, that the present barriers to the full participation of women in science be reduced.

Statistics on the participation of women in science and technology have been presented to the Congress before, and I will not spend a great deal of time on them here. According to the report, Women and Minorities in Science and Engineering, recently issued by NSF, women made up less than 10% of the science and engineering workforce, though they made up over 40% of all professional and related workers. While the increases in numbers of women entering science and engineering show that, under favorable conditions, women will enter these fields, there is still a long way to go. In 1980, for example, only 90 out of the over 2400 engineering doctorates granted went to women. Furthermore, there is much concern among women scientists that current government policies may be a deterrent to further progress, and could result in loss of such progress as has been made.

In order to determine the steps necessary to realize fully the potential contributions of women to science and technology, it is important to identify the present barriers which they face. These barriers are found in two major areas: education and employment. Of these, the barriers which women face to career advancement are the most serious obstacles. Women cannot be expected to undertake the often long and demanding training required for a career in science or technology if they are to be denied the normal professional rewards. A recent study by the National Academy of Sciences has shown that women scientists are still denied equitable access to these rewards. The study examined a sample of women and men scientists matched for field, experience, and educational background, among other factors. It shows a continuing pattern of differential rewards for men and women scientists which cannot be explained on the basis of differences in their backgrounds, professional experience, or life situations. Women employed in colleges and universities are less likely than men to be in tenure-track positions, those who are in tenure-track positions are less likely to be granted tenure than are men with similar qualifications, and women of similar academic rank and experience are paid less than men. These trends are present for recent graduates as well as for those who received their degrees in years past. Women scientists are also more likely to be unemployed or underemployed than are men.

It should not be concluded from these findings that change cannot be achieved. Progress has been made in some areas. Educational barriers have been reduced. Improvements have been made in opening jobs to women at entry level, and in reducing salary discrimination there. These changes have taken place where enforcement of equal opportunity legislation and organizational committment to achieving equal opportunity have been greatest. But in the colleges and universities, where most women scientists are employed, and where enforcement has been weak or absent, there has been less progress.

Equal opportunity in science and technology is a proper concern of this subcommittee; it is a key to effective utilization of our scientific human resources, and the ways in which science and technology are supported can have a great influence on the extent to which it is achieved. As the recent report by Dr. Slaughter, the Director of the National Science Foundation, has indicated, there are many ways in which granting agencies can encourage the increased participation of minorities and women in science and engineering, and more equitable treatment for those who enter these fields, in the context of their present programs. Such efforts are especially significant for women, since a recent survey indicates that programs which specifically address the needs of women in science and technology are rare. The Subcommitee on Women strongly supports Dr. Slaughter's recommendations, and we hope that other government organizations will undertake similar efforts.

In particular, our Subcommittee has concluded that efforts to establish more equitable treatment of individuals who are not in tenure-track positions, both in opportunities to apply for grants, and in treatment of personnel supported by grants would be of substantial value to women scientists, as well as to many male scientists. Women are more likely to be in non-tenure-track positions in the universities, and many institutions do not let such individuals apply for grants. While the policies in question are often those of the colleges and universities, granting agencies can have a substantial impact by providing incentives for change. Where federal funds are involved, responsibility for the impact of the way in which they are used on the scientific and engineering workforce should be among the concerns of the granting agencies.

In the area of specific programs, programs for women reentering science and technology should receive immediate attention. The Executive Director of the Scientific Manpower Commission has estimated that there are over 500,000 women who are potential candidates for reentry programs. The highly successful NSF reentry programs have shown that such programs can be a very cost-effective way of rapidly increasing our supply of scientists and engineers. In as short a time as one year, these programs retrain women to be engineers, computer scientists, chemists, and other needed specialists. It is likely that the increased tax dollars paid by their graduates will more than repay the costs of these programs over the years. Their elimination from the 1982 NSF budget would appear to be a classic example of a "penny-wise, pound-foolish" decision. One of the first steps in any effort to remedy shortages of trained personnel in science and engineering should be to restore funding for these programs.

The reentry programs would also be good candidates for the initiation of government-industry cooperation in efforts to alleviate current and projected shortages in technical personnel. The expertise which NSF has developed in this area could be shared with industries interested in such efforts. Since the graduates of these programs would be of immediate value in meeting the needs of industry, such programs would appear to be excellent candidates for support by those who wish to cooperate in efforts to increase the support of the private sector for science education.

The Subcommittee on Women was very pleased to see that money for the implementation of the Visiting Professorship program, which was authorized, but never funded, has been included in the budget for 1982 and the proposed budget for 1983. This program should have the dual benefits of encouraging talented women students by providing the opportunity for supportive contacts with established women scientists, and also provide recognition and support for the achievements of women scientists.

I would also strongly recommend that the National Research Opportunity Grants, another program which was authorized but never implemented, be funded. Providing research support for women who are starting careers in science, or reentering science after a career break, is a crucial step towards launching them on productive scientific careers. Women scientists, far more often than men, remain in post-doctoral and research associate positions, where they are unable to pursue independent research. Many women scientists strongly support this program, for it addresses the crucial issue of support for the research of women scientists.

The importance of improving opportunities for women scientists as they advance in their careers should not be overlooked. Efforts to promote research opportunities for women employed in colleges which do not have extensive research facilities would be valuable in this regard. Funds for research at research oriented universities in nearby locations would be valuable, as would programs to reduce the heavy teaching load encountered by women in these institutions.

Another serious problem in this area for women scientists has been the selective pattern of the Administration budget cuts in science support. Women scientists are most heavily represented in the social and behavioral sciences, the area which has suffered the most severe budget cuts. While a long-range goal should be to increase the proportion of women in other areas of science and technology, the short-term impact should not be ignored. Moreover, research in the behaviorial sciences, including such areas as how mathematics and science can best be taught and learned, is important to increasing the participation of women in science and technology. Such research will be severely affected by the budget cuts. In this regard, it is encouraging to note some restoration of funds to the behavioral sciences.

In the area of education, the cutbacks in federal support for science education at NSF have been of serious concern to women scientists. The excellent, highly cost-effective science career workshops directed to women students are no longer being funded. Even apart from their impact on programs specifically intended for women, the reductions in these programs have serious implications. Programs in science education which are now being developed in some other agencies, especially in some of the defense agencies, raise questions about whether this method of support is the best route to create effective programs, and some are being implemented in ways which may have the effect, if not the intent, of severely restricting the participation of women. The Women's Subcommittee has expressed its concern on this matter. It would seem reasonable to expect that any program encouraged by the federal government in the area of science education should have women and minorities represented proportionately to their numbers in the target population. Steps should be taken to insure the unbiasing of these programs.

The recent establishment of the National Science Board Commission on Pre-college Education in Mathematics, Science, and Technology, can have a positive impact in this area. Pre-college education related to science, engineering, and technology, can have great impact on the participation of women in these fields. The Commission can serve a valuable function by developing constructive proposals for the education of women in science and technology.

Another concern in the area of access to careers in science lies in the cutbacks in federal support for students. Studies in the past indicate that, in addition to encountering barriers to admission, either thru exclusion, quotas, or in being required to meet higher standards than males, women have suffered financial handicaps relative to males in their access to higher education. The increased availability of federal support for programs of financial assistance to college students helped to remedy this situation in the 1970s. The emphasis on loans may have been a somewhat mixed blessing for women students, since while it has increased their access to education, it tends to leave them with debts which they have fewer financial resources to meet than their male colleagues. However, even this limited improvement is being swept away thru the administration budget cuts. Although provisions requiring equal access to credit for the sexes will continue, the need to earn a larger share of college expenses will fall more heavily on women students, since they are seldom able to earn as much as male students. The alternative sources of funding being suggested appear, in many cases, to be less likely to be available to women. Unless some special efforts are made, many young women from moderate-income families will be effectively barred from pursuing careers in science and technology, or forced to discontinue their educations before they can achieve the credentials for professional level careers in science and technology.

The special needs of particular groups of women must also be addressed. Minority women, handicapped women, and women from poor families, continue to face serious access barriers to careers in science and technology. Cuts in support for science education are likely to have serious negative impact on these groups. While the programs directed towards increasing the participation of women in science and technology have been effective they have received very modest support from either government or private sources, with the result that they have reached only a small fraction of the target population. Minority women report that programs designed for minorities have sometimes neglected the concerns of minority women. Here again there is evidence of the need for monitoring of all federal programs to insure that women are represented in such programs in proportion to their numbers in the target population, and that the content of such programs be designed to be equally appropriate for males and females.

In summary, Congressional action is needed to achieve the full utilization of women in science. Recommended actions include:

> Agencies which fund research should make full use of the opportunities which exist within their present programs to encourage the participation of women in science and technology, and to work towards equitable treatment for women who enter careers in science and technology.
>
> Funding should be provided for the NSF reentry programs for women in science.
>
> Support should continue for the Visiting Professorships Program.
>
> Funding should be provided for science career workshops through NSF.
>
> The National Research Opportunity Grants should be implemented.
>
> Further initiatives are needed to improve research opportunities for mid-career women.
>
> Special attention should be addressed to increasing the participation of minority women, handicapped women, and economically disadvantaged women in science.

The universities should be strongly encouraged to eliminate barriers to grants applications by employees outside tenure-track positions, and granting agencies should establish personnel policies to ensure equitable treatment for those supported by their grants.

Action should be taken to insure that all programs supporting science education include women ~~and~~ as well as men from the target population in proportion to their numbers in that population, and provide programs whose content is appropriate for both sexes.

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Women and Minorities in Science and Engineering, National Science Foundation, 1982.

Mr. **Dymally**. Thank you very much, Dr. Pfafflin.

We will take all the panelists and then come back to the questions and answers.

Dr. Merideth, would you identify yourself for the record, please?

Dr. **Merideth**. Thank you, Mr. Chairman and members of the subcommittee. My name is Charles Merideth, and I am the chancellor of the Atlanta University Center.

I am pleased to be here today to speak on behalf of the National Science Foundation fiscal 1983 budget request in general and to the continued support for programs designed to increase the number of minority professionals in the sciences, mathematics, engineering, and technology, in particular.

I shall not bore you with the well-published statistics on the underrepresentation of minorities and women in the sciences, nor shall I make the case that underutilization of these groups means a waste for this country, but what I shall attempt to do is make the case that the past support from the National Science Foundation and other Federal agencies, in conjunction with some support from the private sector, has made a significant difference in the ability of minority colleges to be responsive to this national problem.

Second, I shall also make a strong appeal to this subcommittee to be responsive to the initiatives that are proposed in the 1983 fiscal budget designed to further impact positively the problem of underrepresentation of minorities in the sciences and mathematics.

On the first point, I think it is clear to us that whatever increases we have observed in the minorities' access to careers in science and engineering has been directly in proportion to the availability of funds either directed to the minority students, directed to the minority institutions, or directed to majority institutions targeted for minority programs.

To support this program, I shall refer to the institutions that I represent—it is there that I am most familiar with the data—but I am sure similar results can be cited for other places as well.

The impact of Federal funding from the National Science Foundation and other agencies, with some help from the private sector, has had a profound effect in our institutions, both at the individual and the institutional levels.

At the institutional level this support has brought to our institutions what I have defined as a certain level of scientific credibility. Further, this support has allowed many of our departments to grow, and we have been able to increase the number of faculty members with terminal degrees.

On the scientific credibility point, the minority scientist and researcher has gained an increased visibility in the community as well as among his or her peers. In our case, this can be seen, in one case, from the increase in the number of scientific publications that are being made possible through Federal and other kinds of support.

Prior to 1972, when our support was very low, the average number of scientific publications coming out of our institutions was around three per year. Since that time, with increased financial support, the number of publications has grown to over 153, with a peak of 37 in 1975. This, in my estimation, represents a dramatic increase in the scientific productivity of our institutions. This productivity would not have been possible without the kind of external support that we are discussing here today.

Further, this increased scientific productivity by our faculty and this scientific credibility that I mentioned have allowed us to get more of our graduates into major universities to study toward advanced degrees.

In addition, we have been able to attract high quality scientists to teaching and research positions, because it is impossible to develop a strong faculty at an institution where there are no research activities, especially in the area of science.

Also, with the increased productivity in the scientific area, we have been able to make the case and have been successful in acquiring a certain level of sophisticated research equipment that was impossible before because of the low level of academic research.

The other important point here is that this targeted support has allowed our institutions, or at least some of the faculty members, to be more competitive in securing funding from nonminority Federal programs. This has been possible to a certain extent because the support from NSF and other Federal agencies has allowed us to establish a supportive research environment.

Many excellent scientists and researchers at our institutions have been denied access to the open and competitive marketplace because the peer reviewers have indicated that they could not believe that they would be successful in achieving what had been proposed in an environment that was not supportive of research.

As a result of the increased scientific capability and credibility that these funds have allowed to develop in our institutions, we have been able to participate on an equal partnership basis with several major universities. For example, we have established a cooperative program with Georgia Tech in the area of atmospheric and geophysical chemistry.

In addition, we have now for over a period of 12 years had a joint program with Georgia Tech in the area of engineering. Here we have experienced some dramatic increases in the productivity of black engineers. Prior to 1969, we had no engineering students in our student body; today we have over 600 engineering students, one-third of whom are female. We also have graduated in excess of 150 black engineers with this program with Georgia Tech.

I would also like to mention here—and Dr. Slaughter mentioned it briefly earlier—the activities of the Resource Center in Science and Engineering financed by the National Science Foundation. As Dr. Slaughter indicated, this program is designed to deal with students on three levels—the precollege, college, and graduate level.

Our program has been successful over the first 3 years of operation in having made contact with over 800 elementary school children in grades 3 to 8 and their parents, 194 high school students and their parents, 722 high school science and mathematics teachers and counselors, and over 400 faculty members from colleges and universities in the region, 80 college juniors and seniors from 31 different institutions, and 40 faculty researchers.

While it is too soon to gauge the long-term impact of the resource center concept, it is clear that we are making progress toward meeting our short-term objectives, but this three-prong approach—precollege, college, and graduate education—I think is in the right direction toward providing equity for minorities in careers in science and engineering.

Lastly, the increased scientific credibility and visibility that these funds have allowed for us have also enhanced our position in the community. Through the Resource Center, as I said before, we have raised awareness of opportunities for careers in science throughout the black community. The Saturday Academy has been a real success. The program has been featured both on "PM Magazine" and in "Newsweek." We are very proud of that.

I would also like to recommend at this point that we consider the establishment of a Saturday Research Academy. I think the Saturday Academy, coupled with a Saturday Research Academy, will give young people an early exposure to the opportunities in science and engineering.

So much for the institutional impact. Let us now look at the individual impact. From direct support from NSF and other Federal agencies, our graduate school at Atlanta University has been able to strengthen its Ph. D. program in biology and has added a Ph. D. program in chemistry. Neither of these activities would have been possible without the assistance of NSF through its Resource Center for Science and Engineering.

In addition, through the Resource Center, a master's degree program in physics and computer science has been initiated to supplement the undergraduate programs in this area. The biology program has produced 19 Ph. D.'s in the last 5 years, and the graduate enrollment in chemistry is at an all-time high this year.

Many students at both the undergraduate and graduate levels have been able to support the cost of education through research fellowships and assistantships. It is my view that this type of student support has some merit against direct student loans and student grants because the students have an opportunity to contribute to the overall scientific productivity of environment while the educational costs have been met.

More than 370 graduate students in chemistry and biology over the last 5 years have received tuition fees and salary support from federally supported research programs. Needless to say, without their support these students, in all probability, would not be in science programs or would not be science professionals pursuing careers in the scientific disciplines.

I would urge this subcommittee to approve the requests from the National Science Foundation in the area of graduate fellowships for minority students. This support, in my view, is an important investment in the future growth and development of our country.

If a drastic drop in enrollment takes place that is expected because of the lack of financial support to students, production of scientists and engineers will also suffer.

I hope that the results that I have given from the AU experience with external support from the Federal Government, including the National Science Foundation, have been revealing. I do not mean to imply in any way that the support has been adequate; the support has been less than adequate. My only point here is to try to show you the kind of impact these external grants have on programs at the minority institutions.

The critical shortage of scientists and engineers in general raises serious questions in regard to our increased technological development, increased productivity, economic recovery, and the effectiveness of our ability to provide for national security.

I would like to borrow a statement from an impressive TV commercial, that many of you might have seen, from W. R. Grace & Co., which says, "America must remain one step ahead of a changing world." Without an increased production of scientists and engineers with the capability to effect new technological developments, we may expect to have to accept the foreign aid that was extended by Japan. This, I feel, would be an untenable position for our great country.

Thank you.

[The prepared statement of Charles W. Merideth follows:]

PREPARED STATEMENT OF CHARLES W. MERIDETH, CHANCELLOR, ATLANTA UNIVERSITY CENTER

BACKGROUND

Mr. Chairman, I am here to speak for the National Science Foundation Appropriation as it relates to the training of minority physical, and natural scientists and engineers, including women. The lack of adequate representation of Black and other minority groups in the physical sciences and in engineering point to a severely underutilized, underserved and un-served human resource in this country. A reason for concern is that too few minority students are earning bachelors, graduate and professional degrees in science and engineering.

The report, Professional Women and Minority - A Manpower Data Resource Service,[1] which was released in February 1981 by the Scientific Manpower Commission, contains data that highlight the magnitude of the problem:

- The 125,000 chemists in the country's workforce include only
  - 1.1% Black
  - 0.7% Hispanic
  - 0.15% Native American

- The 1,385,000 engineers in the workforce include only
  - 2.8% Black (only 0.8% of these are Ph.D.'s)
  - 1.9% Hispanic
  - 0.04% Native American

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[1] B. M. Vetter and E. L. Babco, Professional Women and Minority - A Manpower Data Resource Service, Scientific Manpower Commission, 1776 Massachusetts Avenue, Washington DC, 1981.

- The 55,000 persons employed in the life sciences include only
  - 1.8% Black
  - 1.0% Hispanic
  - 0.1% Native American

- The 431,000 physicians in this country include only
  - 2.0% Black

- The 131,000 dentists in this country include only
  - 2.0% Black

The report substantiates the fact that other minority groups, including Native Americans and Hispanics, are also severely underrepresented in science and engineering fields.

Let me present some general comparative facts on Blacks and other minorities in the United States. This information is based on the 1980 U.S. Census and comes from the publication, "Fact Sheets on Institutional Racism."

Whites	188,340,790	(83.2%)
Blacks	26,488,218	(11.6%)
American Indians	1,418,195	(0.6%)
Asian Americans	3,500,636	(1.6%)
Other	6,756,986	(3.0%)
Total U.S. Population	226,504,825	
Latinos	14,605,883	(16.5%)

Thus, Blacks and other minorities comprise only 16.9% of the total U.S. population.

- In 1979, one out of 12 white males was a service worker, but one out of five females and one out of four minorities held such a job. Comparatively, almost one-third of all white males were in professional or managerial positions; but fewer than one out of four females, and one out of six minorities were in these occupational categories.

- In 1979, there was one Black physician for every 728 Black persons, compared to one white physician for every 484 white persons.

- 75% of whites graduate from high school; only 56% of Blacks graduate.

- Blacks received only 3.5% of Ph.D.'s granted during the 1979-80 academic year. The percentage of Black doctorates peaked at 4.6% in 1977, up from 2.7% in 1973.

- From 1969-77, overall enrollment in medical school increased by 59 per cent. The primary beneficiaries have been white students who continue to be enrolled in numbers far above the proportion of whites in the total population.

- A breakdown of the nation's 62,242 medical school students shows 86.4% are white, 5.7% are Black, 3.6% Latino, 2.6% Asian American, 0.3% Native American, and 1.4% foreign students.

With such statistics as these, and other similar ones not mentioned, it is apparent that concern must be given for the advancement and participation of minorities in the professional and research arena of science and engineering.

INTRODUCTION

The report, A Losing Battle: The Decline in Black Participation in Graduate and Professional Education[2], by the National Advisory Committee on Black Higher Education, calls attention to the decrease in numbers of Black Americans in graduate and professional schools. Data from this report shows an actual decline in the number of Black graduate students since 1976. In 1978, Blacks comprised 5.7% of all graduate students in the United States, down from 6.0% in 1976. In 1978 the proportion of Blacks among full-time graduate students was 4.9%, while in 1976 it was 5.1 per cent. Blacks made up 6.1% of the first year graduate student population in 1978, compared to 6.4% in 1976. Between 1974 and 1977, the percentage of Ph.D.'s awarded annually to Blacks increased from 2.6% to 3.5 per cent. Since 1977, the absolute number of Black Ph.D. recipients has increased only marginally from 1,009 to 1,050 and represents a percentage decrease to 3.2 per cent. If one examines medical school admissions, one finds in 1980-81 that the number of Black students among first year medical school students fell to its lowest percentage level of 5.7% when compared to its peak year of 1974 at which time it was 7.5 per cent.

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[2] A Losing Battle: The Decline in Black Participation in Graduate and Professional Education, National Advisory Committee on Black Higher Education and Black Colleges and Universities, 1100 17th Street, NW; Washington, D. C. 20036, 1980.

The Committee further points out that historically Black colleges continue to play a major role in providing Black students with the opportunities to pursue graduate and professional education. In 1978 the historically Black colleges accounted for 17.8% of all Black graduate students and granted 22.2% of all first professional degrees to Black graduates. In 1976-77, two historically Black colleges out of 58 dental schools conferred 40.2% of all professional degrees to Black dentists; two out of 110 of all medical schools conferred 21.8% of all M.D. degrees to Blacks, and one out of 19 schools of veterinary medicine conferred 82.1% of the DVM degrees to Blacks. Historically Black colleges enroll only 20% of the total number of Black students that are in higher education in this country, but they award almost 40% of the Bachelor degrees bestowed upon Black students. The pattern is evident that fewer Black students are enrolling in graduate and professional education programs and that the proportion of Black graduate and professional degree recipients would be lower had it not been for the historically Black institutions.

The report, Professional Women and Minority - A Manpower Data Resource Service, as shown in the background information, contains data that further point out the magnitude of the problem. Of the 125,000 chemists in the country's workforce, only 1.1% are Black, 0.7% Hispanic and 0.15% Native American. Of the 1,385,000 engineers in the workforce, only 2.8% are Black, 1.9% Hispanic and 0.04% Native American, and only 0.8% are Black Ph.D.'s. Of the 55,000 persons employed in the life sciences, only 1.8% are Black, 1.0% Hispanic and 0.1% Native Americans. Of some 431,000 physicians in this country less than 2.0% are Black, and out of 131,000 dentists, less than 2.0% are Black.

Data from the National Science Foundation's study of Women and Minorities in Science and Engineering[3] show that between 1970 and 1980, women were awarded 10% more science and engineering degrees. At the baccalaureate level, it was found that in 1980 more than 105,000 women earned degrees in the science and engineering fields. Particularly in engineering, the number and proportion of degrees increased from 0.7% (350) in 1970 to 10% (6,100) in 1980. In computer and information sciences, the proportion of degrees earned by women doubled from almost 14% in 1971 to over 28% in 1979, and the number increased from 300 to 2,500. Significant increases have also been found in both the number and proportion of women receiving master's and doctorates in science and engineering. In 1970, 10,000 women received advanced degrees in science and engineering, reflecting only 15% of the advanced science and engineering degrees awarded in these fields. By 1980, the number of women receiving advanced science and engineering degrees had increased to over 18,000, or 25% of the advanced science and engineering degrees awarded. It must be pointed out, however, that women earned almost 50% of all master's degrees and almost 30% of all doctorates awarded in 1980.

- The number of women receiving master's degrees between 1970 and 1980 increased from 8,600 to 14,500 (69%). Although the proportion of women receiving master's degrees increased in all science and engineering fields, the most significant increase was in engineering—from 1% in 1970 to 7% in 1980.

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[3] Women and Minorities in Science and Engineering, National Science Foundation, Washington, D. C. 20550, January, 1982.

- The number of women receiving doctorates in science and engineering fields more than doubled between 1970 (1,600) and 1980 (3,800). Comparatively, the number of men receiving doctorates in these fields decreased from 16,000 to 13,400. Women accounted for 9% of doctoral degrees awarded in science and engineering in 1970 and in 1980 they accounted for 22 per cent.

The National Science Foundation reports further that Blacks, Asians, and other racial minorities earn a small fraction of the degrees awarded in science and engineering, thus collaborating the data of other sources quoted herein. In 1979, Blacks earned 6% of the science and engineering bachelor's degrees awarded and less than 3% of the doctorates. Asians earned approximately 2% of the bachelor's degrees in science and engineering and over 4% of the doctorates. It is interesting to note that 84% of the Asians earning doctorates from United States universities were not citizens.

In the field of engineering alone, the number of Blacks earning degrees has increased significantly since the early 1970's. Between 1972 and 1980 the number more than doubled from 600 to more than 1,300. Despite this increase, only 2% of the science and engineering degrees earned by Blacks were in engineering.

The large disparity between Blacks and other minorities and their nonminority counterparts at all levels of the educational spectrum argues for continued emphasis for intervention strategies at the pre-college level. Hence, such mechanisms as financial incentives, development of pre-college programs to increase minority participation in science and technical fields, allocation of extra resources to high schools with large populations of low-income students, and similar impactive goals must be instituted. At the same time, we must work to enhance the supportive measures and quality of educational resources for those students currently enrolled at the college and graduate levels. Equity in advanced education is an important goal that can be achieved by a combination of appropriate federal, state and institutional responsibilities to ensure all Americans adequate health, legal, technological, and professional services. The alternating periods of encouragement and retrenchment which we have witnessed from federal funding sources appear more a discrete maneuver than a genuine, essential concern for the nation's minority student population. The achievement of adequate representation of minority groups in the professional workforce must continue to be included in this country's goals.

A substantial increase in the production of a cadre of minority professionals is essential to the achievement of equity for minorities in higher education and the society at large. Therefore, the extent to which minorities will impact the decision-making process is dependent upon the degree to which they gain access to and successfully complete graduate and professional pursuits. For the most part minorities must depend upon minority professionals who serve the health care, legal, educational, and leadership needs of most minorities and are familiar with the problems prevalent in a group which has been systematically cut off from the larger society. Therefore, it is extremely significant to realize that the production of minority professionals is essential to the entire framework of achieving both social and educational equity. Such citizens encourage participation in the educational establishment, conduct research, serve on governing boards, and generally bring an added dimension wherever they are present. Equally important, such individuals provide a unique service to the minority community through their roles as informal counselors, advisors, and success models.

FINANCIAL AID

The National Advisory Committee on Black Higher Education has found that in all probability, financial aid is the principal reason for the decrease in numbers of Black students pursuing graduate and professional studies. Blacks find less success than other groups in securing financial aid monies awarded through fellowships, traineeships and scholarships from public and private sources because the competition for such awards becomes more intense as funds become more scarce. Reports of financial support disclosed that Blacks were largely excluded from Federal and institutional funding. On the Federal level, Blacks relied less on fellowships and grant support, especially in the physical sciences and engineering. By contrast, the National Direct Student Loan Program (NDSL), consisting of funds that must be repaid by the student, was more heavily utilized by Blacks than by whites or foreign students and other minority citizens. One reason is the inequity of racial balance to which these funds are contributed. Hence, the biased distribution of Black doctorates, engineers and other professionals.

At the institutional level the Committee found that 23,399 Ph.D.'s cited teaching and research assistantships as a means by which they financed their graduate education. This number included only 399 Blacks (1.7%), compared to 17,232 whites (73.6%), and 5,768 foreign students and other minorities (24.7%). Most of what little financial aid Black graduate students receive is prevalent in the fields of education and the social sciences and is barely existent in science and engineering where Blacks are least represented. Among the 1978 doctorate recipients cited in the National Research Council report, Blacks in engineering received only three, in physical sciences only 21, and in life sciences 38. By contrast, whites reported 360 awards in engineering; international and other minority students reported 91; in physical sciences, whites received 696 and international students ond other minorities 186; and in life sciences, whites cited 1,635 awards and foreign students and other minorities totaled 300.

ACCESS

In the report, A Losing Battle: The Decline in Black Participation in Graduate and Professional Education, the National Advisory Committee on Higher Education found that Black access to graduate and professional study remains a most persistent inequity in the American educational system. This problem is rooted in all educational levels. Blacks have been plagued by a relatively high drop out rate in elementary and secondary schools, thus leading to a low eligibility pool for undergraduate and graduate study. The pool is further reduced by negative counseling and tracking of Black high school students. Many academic counselors, because Blacks are stereotyped as inferior or disadvantaged, steer them into vocational or non-academic programs, cutting short their chances of attending college. Further, it appears that many minority students at the secondary as well as at the undergraduate level are led away from difficult disciplines such as mathematics and physics and guided into "easy" fields, such as education and the social sciences. The Committee found that the resulting product is a pool of minority students with inadequate academic preparation to pursue advanced degrees in areas of science and technology because students have not had the opportunity to gain the basic mathematics and science requisites at the secondary and undergraduate levels.

Access Summary

- Nearly all educational Federal support for students is geared to access. Consequently, very little has been done to ensure Blacks and other minorities a chance to complete their baccalaureate with the same ease as their better prepared and more economically secure white classmates.

- Admissions tests also share in the responsibility for the exclusion of Blacks from graduate and professional education. These tests have been criticized as being culturally biased in favor of white middle class citizens. As long as test scores remain one of the most important criteria for selection and as long as Blacks receive lower scores than their majority counterparts, then admissions tests will continue to disqualify larger numbers of prospective Black graduate and professional students.

- Graduate and professional school selection committees continue to prefer low-risk students with impeccable academic credentials and fail to take into account the educational and socioeconomic backgrounds of most minority applicants. Thus, graduate schools spend little effort recruiting minorities who may require curriculum modifications and supportive services to increase their chances for academic success.

- Finally, the increasing expense of graduate education is detrimental to minorities who want to advance to this level. Since many minority students are forced to borrow heavily to finance their undergraduate education, further loans for graduate or professional study are not feasible.

The proportion of total Federal education expenditures designed for graduate and professional education declined markedly in the 1970's and the competition for private foundation fellowships and grants has grown acutely intense. Without some redress of the current situation, the specter of ever diminishing Black participation in graduate education accessible only to the economic elite looms as more than exaggerated paranoia.

THE NATIONAL SCIENCE FOUNDATION

The 1981 National Science Foundation (NSF) Authorization Act (Public Law 96-516) calls for the Director of the NSF to transmit to Congress and selected Government officials a biennial statistical report on the participation of women and minorities in science and engineering employment and training. In response to that request, the first volume of this report, "Women and Minorities in Science and Engineering," was issued in January 1982 and its inclusive data, collected from the 1978-79 period, confirmed that the level of participation of minorities in these fields is low. The report shows that this problem is, indeed, related to the extent to which minorities participated in math and science training at all school levels.

This endeavor by the National Science Foundation provides assurance that this Federal agency, because of its research in this area and resultant awareness of the problem, will do what is necessary to aid in the alleviation of this problem.

Toward this end, Dr. John B. Slaughter, Director of the NSF, has stated that "The realization of national goals in the decade of the 1980s—sustained, real economic growth, enhanced national security, and improved quality of life for all citizens—depends critically on the continued flow of new knowledge, technology and trained scientists and engineers from the nation's investment in basic research. ...The budget request for FY 1983 was developed within the context of the President's economic recovery program. As part of NSF's contribution toward the achievement of that program's objectives, all activities and priorities were carefully reviewed to insure that those included in the FY 1983 request would provide the largest possible return on the dollars invested in terms of a strong scientific and engineering knowledge base for the future." This important thrust projected by NSF must include in its funding decisions and activities our severely underutilized minorities so that this country can draw upon them for the continued development of its society.

Further, Dr. Slaughter has pointed out that the relative underrepresentation of women and racial minorities in science and technology weakens national capabilities in industrial output, productivity growth and national defense. In addition, shortages of highly skilled personnel in particular areas of science and technology are exacerbated by this underrepresentation. The FY 1983 NSF budget will address this issue by providing several different programs.

- The Minority Research Initiation Program, which provides support to members of ethnic minority groups, will fund about 50 new and 90 continuing awards. Support of this particular program will be increased by 47% to a total of $2.5 million.

- The Visiting Professorships of Women program will be increased by 50% to a total of $1.0 million FY 1983.

- The Research Improvement in Minority Institutions program will be quadrupled in the FY 1983 budget to a total of $2.0 million.

The Foundation's major responsibilities will lie in graduate education and training in research and in monitoring and evaluating personnel trends and the status of science and engineering education. In primary and secondary education NSF can play an important role by helping to identify critical needs and by encouraging scientific and professional societies, academic institutions, state and local governments, private industry and other Federal agencies to work together to meet these challenges.

RECOMMENDATIONS

There must be a wider federal role in increasing the participation of women, Blacks and other minorities in the physical and natural sciences and engineering, because the private sector of foundations and corporations have been responding erratically and somewhat selfishly, and never at the level of required resources. Therefore, the following recommendations are made so that the National Science Foundation can continue to be even more responsive to the needs of Blacks and other minorities:

- o Support of new Comprehensive Graduate Centers in the Physical and Engineering sciences at different minority institutions, especially at historically Black colleges. In addition, the initiation of a National Review Committee of Scientists to evaluate the operation of the Centers and to monitor their continued development.

- Continuing support of Resource Centers in Science and Engineering, including elementary, high school, undergraduate and graduate components.

- Implementation of special programs to get more high school students into undergraduate colleges, such programs as Saturday Science Academies and other research academies operated by colleges and universities for high school students and Science and Engineering Work-Study Programs. Especially include programs to advance non-college bound students into undergraduate schools in science and engineering.

- Develop a science-oriented atmosphere in elementary and secondary schools to increase awareness among minorities so that they may be as academically qualified and prepared for graduate study as whites.

It is clear that a better job needs to be done of motivating our young minorities to study physical science and engineering. It is hoped that the implementation of these recommendations will ensure that funding sources, especially those at the federal level will become more genuinely concerned for racial equity and more strategic in their disbursement of resulting grants, fellowships and financial awards.

CONCLUSION

We are grateful for the bright spots in the picture afforded by federal programs targeted toward minority involvement, especially the NSF, which is the Federal government's most active agent in advancing the state of scientific research. The foresight and courage that urges public officials to continue the fight for the minority effort is truly inspiring.

Mr. **Dymally**. Thank you.

Dr. Mann, what I plan to do is to have you make your statement, then call Dr. Slaughter just for a few minutes so that Mrs. Heckler can ask some questions, and then bring the panel back for some questions.

Dr. **Mann**. Fine.

Mr. **Dymally**. Fine. Would you proceed then?

[The biographical sketch of Dr. Mann follows:]

BIOGRAPHICAL SKETCH

Robert W. Mann

Robert W. Mann's career revolves around engineering design. Following vocational high school, employment as a draftsman at the Bell Telephone Laboratories and military service in the Southwest Pacific in World War II, he completed his S. B. (1950), S. M. (1951) and Sc.D. (1957), all in Mechanical Engineering at M.I.T. As a design engineer in the Dynamic Analysis and Control Laboratory (DACL) at M.I.T. and head of its Design Division, he supervised the design development and test of missile components, some still in use in the Sparrow and Hawk Missiles. In 1953 he was appointed Assistant Professor in Mechanical Engineering; as of 1957 he assumed responsibility for the Engineering Design Division of the academic department, while converting the DACL into the Engineering Projects Laboratory in order to involve more students more intimately in the research, design and evaluation of real engineering devices. The educational approaches and techniques in engineering design education and in project laboratories originated by Professor Mann between 1957 and 1967 have become standard in universities worldwide.

After a period of research involvement in computer-aided design in the early 1960's, Professor Mann's research, and therefore teaching, oriented towards the rehabilitation of the blind and amputees. Computer programs to translate into braille, braille typewriters and braille-augmented telephone switchboards, ultrasonic mobility aids for the blind traveller, the "Boston Elbow" and "Utah Arm" prostheses for the upper-extremity amputee are among Professor Mann's projects which have reached practical application. His current work ranges across human rehabilitation, degenerative arthritis and skeletal joints, and biomechanics.

Over the years he has participated in and chaired many governmental and national committees and meetings, advising and developing policy in engineering design and human rehabilitation. He has been issued several patents, authored over one-hundred-and-seventy-five publications, and has received awards in design education, photogrammetry, sensory aids for the blind, the IR-100 Award for innovative design, United Cerebral Palsy Goldenson Award for outstanding technological research for the handicapped, the American Society of Mechanical Engineers' Gold Medal and Lissner Biomedical Engineering Awards, and the New England Engineering Society Award. At M.I.T. he has been appointed to the Germeshausen Chair and now the Whitaker Professorship in Biomedical Engineering, as well as receiving the M.I.T. Alumni Association "Bronze Beaver." He has been elected to both the National Academy of Engineering and the Institute of Medicine of the National Academy of Sciences. He is a Fellow of the American Academy of Arts and Sciences, of the American Association for the Advancement of Science and of the Institute of Electrical and Electronics Engineers. Professor and Mrs. Mann reside in Lexington, Massachusetts. Robert W. Mann, Jr., M.I.T., S. B., 1975, S. M., 1977, is Manager of Market Planning for American Airlines, and Catherine L. Mann, Harvard, 1977, is a Doctoral candidate in Economics at M.I.T.

Dr. **Mann**. Thank you, Mr. Chairman and members of the subcommittee. I welcome the opportunity to offer testimony on the NSF program on science and technology to aid the handicapped.

To properly address this issue, I first want to identify my interest in rehabilitation research and then relate the NSF effort to other Federal programs and those of the private agencies.

You have my biographical sketch, but let me summarize by noting that I have been at MIT since obtaining my undergraduate degree there on the GI bill. I am on the faculty now for 30 years. My pedagogical mode is the classical one of faculty supervisor of the research of graduate students, and undergraduates as well, who in producing these, develop themselves for professional careers in both engineering and the sciences in industry and for faculty positions. I am very proud of the hundreds of my students who are actively replicating my efforts both in commerce and academe.

Perhaps it would be appropriate to note that the first decade (1950-1960) of that research was concerned with air-to-air missiles done in close cooperation with Raytheon and Sperry and supported by the then-Department of Navy. Hardware that my students and I researched and designed in that decade still fly in the Sparrow and Hawk missiles.

Then I addressed computer-aided design research. In fact, my group originated the label "computer-aided design." But for the past 20 years my students, my faculty colleagues, and I have been undertaking research and development on behalf of the physically handicapped.

Beyond significant research publications,[1] I again want to stress that I am a hardware-oriented person. Hardware that I identify with now currently benefits amputees, those with movement pathologies, the deaf, the severely visually impaired and the blind, stutterers, nonverbal children, et cetera. So I have experience with the process which starts with a research hypothesis and advances through to an end product which has utility in the field for the person for whom the product is intended.

Over these 20 years I have had the opportunity to serve on virtually all major committees and studies in the National Research Council, the National Academy of Sciences, and the National Academy of Engineering, which have formulated or attempted to formulate policy on the technological response to handicapping conditions.

I take great satisfaction in having contributed to the Rehabilitation Act of 1978—which I will come back to—and with the specific NSF program with which you are now concerned, which, as I recall, grew out of the interest of Mr. Olin Teague in the area of the physically handicapped.

I also feel that I can appreciate the handicapped individual's point of view. Throughout this panel's discussion, the common thread is the difficulty normal healthy persons of the dominant sex—I use that term with great qualification—the presumed dominant sex—and of the predominant color have in understanding the points-of-view and concerns of those who are on the other side of each of the above juxtapositions.

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[1] Of my 175 publications (list attached) 125 are in rehabilitation—the earlier papers deal with research on missiles and computers-aided design.

Over the years I have made serious efforts to try to understand the problems of the handicapped from their point of view. Among other things I have served on the board and as president of the largest rehabilitation facility for the blind and severely handicapped in New England and, most recently, on a gubernatorial transition team planning services to the handicapped in the transition from the Dukakis to the King tenures in the Commonwealth of Massachusetts.

The NSF program on science and technology to aid the handicapped must be understood in the larger context of the national effort applying research and development on behalf of disabled persons, and this in turn must be juxtaposed against the national need of disabled persons.

In these remarks, with the bounds of time, I must necessarily be brief and direct, but I have appended several publications to these remarks which expand upon these comments,[1] [2] and they in turn branch out into other publications which I believe are also germane.

Handicapping conditions seriously affect over 40 million Americans. In 1977, the cost of disability payments through social security, pensions, and other programs was $114 billion annually; the current figure must mirror the sharp rise in overall national expenditures for health in the intervening 4 years.

Disablement and handicapping conditions are the melancholy residue of a congenital defect, a trauma or a disease, which at its outset represented an acute threat on the patient's health, or even life. We invest over $3 billion a year of taxpayer money in the National Institutes of Health in what everyone agrees is a productive effort to understand the basic science of underlying disease and to explore appropriate therapy. But unfortunately, disablement and concommitant handicapping conditions are all too frequently the inevitable consequence of even successful health intervention. Beyond disease, the increasing propensity of our society to violence and accident yields further damaged bodies. And the very success of medicine in sparing the infant, in combination with our increasingly complex gene pool and environmental pollution agents, produce an ever-higher incidence of congenital defects.

In remarkable contrast to our significant investment in understanding and remedying life-threatening processes, as a society we invest only one one-hundredth of the NIH budget in the analogous National Institute of Handicapped Research, whose budget has yet to exceed $30 million a year. I note that in 1978 legislation the Congress, in its wisdom, recommended $50 million for NIHR for fiscal year 1979 rising to $100 million for fiscal year 1982.[3] Mind you, I am delighted that the NIHR exists, but it cannot begin to address, the variety and the magnitude of the problems that the handicapped and disabled persons experience.

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[1] Mann, Robert W., "Technology for Human Rehabilitation," Tech. Review, vol. 81, No. 2, November 1978, pp. 44–52.

[2] Mann, Robert W., "Cost Benefits of the New Technologies—The Engineering View," Proceedings of Communications Technology and the Elderly: Issues and Forecasts, to be published by Springer Publishing Co.

Rehabilitative research and development in the Veterans' Administration is significant at about $7 million a year, and we discuss here the NSF science to aid the handicapped program funded at some $1.6 million annually. In aggregate, the NIHR, VA and NSF R. & D. programs for rehabilitation are by any measure extraordinarily modest relative to the national need whether measured in human terms or by economic measures, where it has been demonstrated time and time again that rehabilitation more than repays its initial investment in reduced support costs and in tax revenue.

Interagency coordination in rehabilitation R. & D. has been excellent although I am intrigued and disturbed by reports that members of the Interagency Committee on Handicapped Research apparently were not informed of NSF's intent to zero fund its science and technology programs for the handicapped. The Rehabilitation Act of 1978, section 203, mandated such exchange of program information.

The Federal program's effectiveness, despite the modest funding is, in part, a reflection of a careful delineation in role and approach of the several components of the Federal Establishment. There has been excellent coordination among NIHR, NSF, VA, and the other agencies who play minor roles, but they all collectively recognize, as does NIHR, that the current appropriations cannot cover the universe of rehabilitation needs and opportunities.

NIHR concentrates, through the rehabilitation engineering centers—one of which I participate in, the Harvard-MIT Rehabilitation Engineering Center—and the rehabilitation research and training centers, on the support of clinical environments which also boast strong engineering components either within one university or, as in our case, interuniversity, or through university-hospital collaboration.

Close to, if not in, the rehabilitation clinic, NIHR projects tend to be applied research with clearly defined patient population targets and relatively short-term outcomes. NIHR is explicitly concerned with technology transfer, achieving manufacture and marketing in our free-enterprise economy of rehabilitation devices to insure that the fruits of R. & D. will be available to handicapped persons.

The Veterans' Administration rehabilitative engineering R. & D. program is similar in scope, organization, and applied nature to NIHR, but, of course, centers its efforts in Veterans' Administration medical centers, and the two rehabilitative engineering research and development centers at the VAMC's at Palo Alto, Calif., and Hines, Ill., which combine clinical and engineering talents. Proposals of external origin must be forwarded through, and achieve the collaboration of, medical personnel at the VAMC's.

By contrast to the medically based, more applied, patient specific, shorter time-scale research and explicit development posture of the NIHR and the VA, the program that we address this morning, the National Science Foundation's science and technology to aid the handicapped, consistent with the basic science stance of NSF, stresses long-term research addressing fundamental issues to expand the knowledge base which may ultimately lead to products, treatment methods, or societal and environmental changes of significant benefit to the physically handicapped.

The NSF program explicitly excludes clinical research. The more basic orientation of STAH offers a more attractive avenue for the really new idea, the concept which falls outside of conventional disciplinary bounds, or for feasibility research on a concept which, if promising, will entail a long gestation period. The application of the standard NSF proposal review process offers a better prospect that radical ideas will get a fair, yet rigorous, hearing. This is particularly true for proposals from physical scientists and engineers from a university setting who are not collaborating with physicians.

Specific examples which come to mind are very technical proposals on advanced instrumentation applicable to communication for the blind, the unusual concept of using trained monkeys as aids to quadraplegics and the enormously popular contest held to demonstrate how personal computers are aiding handicapped persons in education, vocation and recreation.

I emphatically disagree with Dr. Slaughter's comment this morning that the STAH program is not at risk because it will be folded into the programs supported under the engineering directorate. I have been engaged in engineering research for 30 years during which time I have reviewed NSF proposals and I know full well the dominance of disciplinary convictions. For example within the NSF, the mechanical engineering people feel very strongly about supporting more or less down-the-line mechanical engineering stuff. The same is true of electrical engineering, computer science, and what-have-you.

I submit that the NSF Directors' argument that new proposals which have a handicapped relevance will be evenly and fairly treated by NSF management and in NSF peer review system is unduly optimistic. In fact, among other things, they will certainly not be reviewed by panels which include handicapped people, which has been one of the features of the current NSF STAH program. Also, most handicapped-oriented research is intrinsically interdisiplinary. Therefore I believe that new proposals vis-a-vis handicapped will find very tough sledding when compared to engineering disiplinary proposals.

In fact, the creation of NIHR in the first place—the Rehab Act of 1978—was a real breakthrough, because we finally had an agency preoccupied with handicapped research. Why do you suppose the names of the categorical Institutes of NIH keep getting renamed and augmented with different diseases? To create foci, to emphasize specific problems!

If handicapping authorization disappears as a goal in the NSF program, I submit that the support will disappear. If you have an interest in further development of this point in the question period, I can cite two specific proposals where I believe, in fact, this has already happened.

I believe that the termination of support for STAH will cut off the flow of novel and potentially invaluable proposals and will have the effect of concentrating the very modest Federal support of rehabilitative R. & D. on shorter range, clinically oriented projects for which the fundamental underpinnings already exist.

We have here the classical problem of using up our "seed corn." We have a very limited supply of "seed corn"—of relevant basic research—in handicapping areas. The NSF program has been a major contributor.

A further unfortunate concomitant of zero funding of this program is the drying up of proposals which have become fundable through the STAH program under the small business innovation research program of NSF. This has been a marvelous kind of marriage. An idea that had merit could have fundamental research conducted under STAH, and then be picked up within NSF by the small business program. Although such financial support is not accounted for under STAH, five phase I and one phase II grants have been awarded; these offer the double promise of handicap-significant R. & D. and the encouragement of small business enterprise to market the rehabilitation product.

I feel particularly frustrated that, at a time when the Congress is disposed toward an increase in the support of research for small business innovation—which I enthusiastically support, because that is where the new ideas turn into products; that is where most new employment occurs—we are going to dry up the channel of NSF handicapped-oriented research which feeds into new business ventures.

Let me mention that private agencies, like United Cerebral Palsy, Paralyzed Veterans of America, and others, have historically encouraged and supported rehabilitation research. While each of these organizations is important and it is to be hoped that their purview and resources can rise to compensate for part of diminished Federal expenditures, each organization has a quite restricted mandate and limited resources, precluding their filling the gap left by the termination of NSF/STAH.

In summary, the disabled constitute a large, increasingly organized, and vocal subpopulation. The Federal research response, although modest, has been cost effective. Elimination of the NSF component leaves a large injurious gap in the support of more venturesome long-range, fundamentally based, interdisciplinary rehabilitation research.

Investment in such research, whose history shows leads to sophisticated technology—I would be happy to give you chapter and verse for examples—enhances the independence and effectiveness of handicapped persons and is repaid many times over in savings in public assistance programs and through tax returns.

I hope that my remarks will contribute to a reconsideration of the zero funding in the 1983 budget of the NSF program on science and technology to aid the physically handicapped.

Thank you.

[The prepared statement of Dr. Mann follows:]

STATEMENT BY DR. ROBERT W. MANN

WHITAKER PROFESSOR OF BIOMEDICAL ENGINEERING

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

March 4, 1982

Mr. Chairman and Members of the Subcommittee:

I welcome the invitation to offer testimony on the N.S.F. Program on Science and Technology to Aid the Handicapped. To properly address the issue, I first want to identify my interest in rehabilitation research and then relate the N.S.F. effort to other Federal programs and those of the private agencies.

You have my biographical sketch, but let me summarize by noting that I have been at M.I.T. since my return from WWII. For the past twenty years my faculty colleagues, my students, and I have been conducting research and development on behalf of the physically handicapped. Beyond significant fundamental research and subsequent publication,* I have participated in the design and technology transfer of what has become commercially available hardware and software which currently benefit limb amputees and persons afflicted with movement pathologies; blind and severely visually impaired persons; deaf-blind persons; children and adults with such severe motor involvement that they cannot communicate verbally; persons who stutter--to mention our primary catagories of rehabilitation research. I have served on virtually all major committees and studies in the National Research Council, the National Academy of Science, and National Academy of Engineering which have formulated policy on the technological response to handicapping conditions over these two decades, including those which contributed to the Rehabilitation Act of 1978 and the specific N.S.F. Program with which you are now concerend. I feel I appreciate the handicapped consumer's point-of-view since, among other roles, I have served on the Board and as President of the largest rehabilitation facility for the blind in New England and have been a member of a Commonwealth of Massachusetts Gubernaturial Transition Team planning services to the physically handicapped.

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*Of my 175 publications, 125 are in this field--the earlier papers deal with research on missiles and computer-aided design.

The N.S.F. Program for Science and Technology to Aid the Handicapped (NSF/STAH) must be understood in the larger context of the National effort applying research and development on behalf of disabled persons, and this in turn must be juxtaposed against the National need. I must necessarily be brief and direct in these remarks, but append to this record several publications which expand upon these comments.[1,2]

Handicapping conditions seriously affect over forty-million Americans. In 1977, the cost of disability payments through Social Security, pensions,

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*1. Mann, Robert W., "Technology for Human Rehabilitation," Tech. Review, Vol. 81, No. 2, Nov. 1978, pp. 44-52.

2. Mann, Robert W., "Cost Benefits of the New Technologies - The Engineering View," Proceedings of Communications Technology and the Elderly: Issues and Forecasts, to be published by Springer Publishing Co.

and other programs was $114 billion dollars annually; the current figure must mirror the sharp rise in overall National expenditures for health in the intervening four years.

Disablement and handicapping conditions are the melancholy residue of a congenital defect, a trauma or a disease, which at its outset represented an acute threat on the patient's health, or even life. We invest over three-billion dollars a year of taxpayer money in the National Institutes of Health in what everyone agrees is a productive effort to understand the basic science of underlying disease and to explore appropriate therapy. But unfortunately disablement and concommitant handicapping conditions are all too frequently the inevitable consequence of even successful health intervention. Beyond disease, the increasing propensity of our society to violence and accident yields further damaged bodies. And the very success of medicine in sparing the infant, in combination with our increasingly complex gene pool and environmental pollution agents, produce an ever-higher incidence of congenital defects.

In remarkable contrast to our significant investment in understanding and remedying life-threatening processes, as a society we invest one one-hundredth of the N.I.H. budget in the analogous National Institute of Handicapped Research, whose budget has yet to exceed 30 million dollars a year. Rehabilitative Research and Development in the Veterans Administration is significant at about 7 million dollars a year, and we discuss here the NSF/STAH at some 1.6 million dollars annually. In aggregate, the N.I.H.R., V.A. and N.S.F. R&D programs for rehabilitation are by any measure extraordinarily modest relative to the National need whether measured in human terms, or by economic measures, where it has been demonstrated time and time again that rehabilitation more than repays its initial investment in reduced support costs and in tax revenue.

Interagency coordination in rehabilitation R&D has been excellent and promises to continue so. This success is in part a reflection of a careful delineation of role and approach of the several components of the Federal establishment. N.I.H.R. is the lead agency, but they recognize their appropriations cannot cover the universe of rehabilitation R&D needs and opportunities. N.I.H.R. concentrates, through the Rehabilitation Engineering Centers and the Rehabilitation Research and Training Centers, on the support of clinical environments which also boast strong engineering components, either within one university or through inter-university or university-hospital collaboration. Close to, if not in, the rehabilitation clinic, N.I.H.R. projects tend to be applied research, with clearly defined patient population targets and relatively short-term outcomes. N.I.H.R. is explicitly concerned with technology transfer, achieving manufacture and marketing in our free-enterprise economy of rehabilitation devices to insure that the fruits of R&D will be available to handicapped persons.

The Veterans Administration Rehabilitative Engineering R&D Program is similar in scope, organization, and applied nature to N.I.H.R., but, of course, centers its efforts in Veterans Administration Medical Centers, and the two Rehabilitative Engineering Research and Development Centers at the V.A.M.C.s at Palo Alto and Hines, which combine clinical and engineering talents. Proposals of external origin must be forwarded through, and achieve the collaboration of, medical personnel at the V.A.M.C.s.

By contrast to the medically based, more applied, patient-specific, shorter-time-scale research and explicit development posture of the N.I.H.R.

and V.A., the NSF/STAH, consistent with the basic science stance of N.S.F., stresses long-term research addressing fundamental issues to expand the knowledge base which may ultimately lead to products, treatment methods or societal and environmental changes of significant benefit to the physically handicapped. S.T.A.H. explicitly excludes clinical research. The more basic orientation of S.T.A.H. offers a more attractive venue for the really new idea, the concept which falls outside of conventional disciplinary bounds, or for feasibility research on a concept which, if promising, will entail a long gestation period. The application of the standard N.S.F. review process offers a better prospect that radical ideas will get a fair, yet rigorous, hearing. This is particularly true for proposals from physical scientists and engineers from a university setting who are not collaborating with physicians.

Specific examples which come to mind are very technical proposals on advanced instrumentation applicable to communication for the blind, the unusual concept of using trained monkeys as aids to quadraplegics and the enormously popular contest held to demonstrate how personal computers are aiding handicapped persons in education, vocation and recreation. The termination of support for S.T.A.H. will cut off this flow of novel and potentially invaluable proposals and will have the effect of concentrating the modest Federal support of rehabilitative R&D on shorter-range, clinically oriented projects for which the fundamental underpinnings already exist. This "seed corn" is already being exploited; the future supply is at considerable risk.

A further unfortuante concommitant of zero-funding of NSF/STAH is the drying up of proposals to that program which have become fundable under the N.S.F. Small Business Innovation Research Program. Although such financial support is not accounted for under S.T.A.H., five Phase I and one Phase II grants have been awarded; these offer the double promise of handicap-significant R&D and the encouragement of small business enterprise to market the rehabilitation product. I find it particularly ironic that proposed increase of Federal research support to small business enterprise comes just as the channel for rehabilitation-related research proposals into small business enterprise is being eliminated.

Let me mention that private agencies, like United Cerebral Palsy, Paralyzed Veterans of America, and others, have historically encouraged and supported rehabilitation research. While each of these organizations is important and it is to be hoped that their purview and resources can rise to compensate for part of diminished Federal expenditures, each organization has a quite restricted mandate and limited resources, precluding their filling the gap left by the termination of NSF/STAH.

In summary, the disabled constitute a large, increasingly organized and vocal sub-population. The Federal research response, though modest, has been cost-effective. Elimination of the N.S.F. component leaves a large, injurious gap in the support of more venturesome, long-range, fundamentally based rehabilitative research. Investment in such research, which history shows leads to sophisticated technology, enhances the independence and effectiveness of handicapped persons and is repaid many times over in savings in public assistance programs and through tax returns.

I hope that my remarks will contribute to reconsideration of the zero-funding in the 1983 budget of the National Science Foundation Program of Science and Technology to Aid the Physically Handicapped.

Thank you very much.

COST BENEFITS OF THE NEW TECHNOLOGIES

THE ENGINEERING VIEW

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COMMUNICATIONS TECHNOLOGY AND THE ELDERLY:

ISSUES AND FORECASTS

October 1981

the Center on Aging and Health

Case Institute of Technology
Case Western Reserve University

To be published by Springer Publishing Co.

COST BENEFITS OF THE NEW TECHNOLOGIES - The Engineering View

When asked by Marie Haug to discuss the cost-benefit aspects of the new communication technologies vis-a-vis the elderly from an engineering point-of-view, I balked, primarily because I did not consider myself an authority on aging. Having participated in this meeting, and now the next-to-last speaker, I am better informed, though hardly an instant expert. But I have been engaged for now twenty years in applying technology to ameliorate handicapping conditions, and it is an inescapable fact that many handicapping conditions are concommitants of the aging process. So, I will respond from that vantage point.

Cost-benefit statistics as an indicator of worth leaves me most uneasy. I am reminded of "in a society where statisticians thrive, liberty and individuality are likely to be emasculated"(Moroney, 1951). But then, as I tell my students, they (and we) have an obligation to assemble all relevant information, but then not be overwhelmed or have our vision unduly distorted. Inescapably, there is a dynamic tension between statistics and human aspiration which for this conference comes down to "quality of life"--a measure not susceptable to cost-benefit quantification.

With these caveats, I can offer some relevant numbers, detailed more extensively in a comprehensive chapter I authored on rehabilitation technologies for humans suffering severe visual and auditory deprivation. (Mann, 1974)

Of the estimated over one-million Americans with severe vision problems in the early 1970's, over 65 percent were sixty-five years of age or older. With the progressive aging of our general population, this percentage can only increase. Within this age-disability group, 60 percent were activity limited due to visual problems. Whereas 16 percent of the general population over sixty-five years were in the labor force, only 6 percent of the comparable group with severe visual impairment were either employed or looking for work.

In 1970, over $700,000,000 were expended by private, state and federal agencies in direct services to the visually impaired, but this effort reached no more than 20 percent of those eligible. To emphasize the life-time costs of visual impairment, a 1967 study (with future costs discounted at an annual 5 percent!--shades of contemporary inflation!) estimated a present value life-time cost of 4.02 billion dollars for a specific sub-population of 67,500 persons under sixty-five years of age with severe visual loss.

The same chapter (Mann, 1974) cites annual costs consequent to auditory impairment--in 1969, an estimated $400,000,000 for the direct cost of services and compensation. The income loss resulting from hearing difficulty was estimated at 1.2 billion dollars annually.

In a more recent article (Mann, 1978) using more current data, I reported the annual national cost of disability payment--Social Security, pensions and other programs--totalling 114 billion dollars. More poignant social statistics: Two million of the severely disabled are homebound, and nearly that many are in institutions; the incomes of severely disabled people average half those of the able, and some four million disabled had income below the poverty level; whereas 30 percent of the disabled national population had attended college, only 9 percent of the severely disabled had.

So, the cost side of the support system of the handicapped, most of whom are elderly, and the lost income represent very large sums indeed.

The Federal government response to handicapping conditions over the past two decades has been dominated by the concept of vocational rehabilitation with an annual budget for direct services approaching one-billion dollars a year. While re-employment of the physically handicapped is an attractive argument, especially before Congress, as a means of reducing service costs and increasing income tax revenue, the policy gave short shrift to the unemployable whether because of severity of the handicap or of post-retirement age. Efforts in advisory agencies to government (N.A.S., 1976) and within government (U. S. G.P.O., March, 1978) led to legislation (House of Rep., 1978) which has broadened the purview to include all handicapped persons whether employable or not--the only equitable approach.

Handicapping conditions are almost always irreversible, frequently but not necessarily chronic, and not usually life-threatening. Most handicapped persons live full spans which are close to normal. The true dimensions of handicapping, whether viewed from the individual's or societies' perspective, must include this longitudinal consideration; statistics on handicapping must encompass the economic and social costs of lifetimes of impaired capability. This concept that illness must be measured in terms of its social burden is beginning to gain acceptance, and we are now seeing data for diseases showing such dimensions as potential years of life loss, days in hospital, physician office hours, lost work days, limitations of major activities, and total economic costs (Rice, Feldman and Wright, 1976).

The foregoing material provides some indication of the costs to the society which are a consequence of handicapping conditions and the aging process. Let me now turn to the cost of the technological response to handicapping conditions--the effort to compensate for biological loss through appropriate devices. Two general classes of response can be considered: First, the actual technology employed is either already existent or is being developed for general public sale, but in either case can be exploited for handicapped and aging populations; and second, the device technology must be specialized to respond to the unique needs of certain catagories of handicapped persons.

Several presentations in this Conference describe the effectiveness of exploiting existing technology. The two cable television examples illustrate how a widely applied and well-accepted new technology can be specialized to the elderly's needs (Richter, 1982) or have the elderly and handicapped persons needs subsumed within the capability of a system designed for the general public (Woolley, 1982). An even more delightful illustration exploiting a very old technology was the Veterans Administration's demonstration of communication outreach to persons with speech, language and hearing problems (Vaughn, 1982) using the telephone and a writing tablet originally developed in the 1920's for railroad telegraph dispatching. When satisfying the needs of the handicapped and elderly can capitialize on in-place technology, the issue is not new devices, but rather creative, thoughtful, responsible, cost-effective system development and application.

I can now turn to the second area in which I speak from personal experience--the research and development of de novo devices and systems addressing specific visual and auditory impairments. Let me start with a global economic overview of the national response. Earlier I noted an estimated cost of $700,000,000 for services to the blind in 1970. In that same year, the most charitable estimate of the total national investment in research and development of devices to aid the blind and severely visually impaired was less than $1,000,000--less than one-tenth of 1 percent of the cost of servicing that population. I stress this point to mitigate the oft-heard complaint that a lot of money has been spent on very sophisticated high technology with very little useful result. When the R&D investment, even in very stable markets, falls below 5 percent of gross, future prospects are at serious risk. In more dynamic fields, such as computers, the R&D investment can be several times 5 percent.

Another global comparison--in a National Academy of Sciences study I conducted addressing sensory aids research (Mann, 1968), I compared Federal research commitments across several major disease and impairment categories, in each case normalized by the number of extant patients potentially affected by the research. Here is the way that broke down then: $220 per cancer patient; $76 per cardiovascular patient; 50 cents per visually handicapped patient. I am not suggesting any onorous ranking of disease importance. But if a society chooses to invest five hundred times as much on one disabling state relative to another, it must accept the consequences in terms of productivity. One final economic observation--this a current one--the annual budget for the National Institutes of Health addressing the categorical diseases, represented by their individual institute names (e.g., Cancer, Heart Blood Lung, etc.), is now about three-billion dollars a year, almost entirely devoted to research--the "R" of R&D. By comparison, the new National Institute of Handicapped Research of the Department of Education (mandated by the 1978 legislation) has an annual budget of about $30,000,000 to cover research and development for all physical and mental handicapping conditions. Thus the Federal rehabilitation research and development response to all permanent impairment arising from any congenital, trauma or disease path is budgetted at one one-hundredth of the research addressing disease etiology and acute therapy.

To treat fairly the costs of the new communications technology for the handicapped, I have to elaborate the technological research and development process leading to a product in the market place. Figure 1 diagrams this "commercialization" process. Note that while R&D is vital to the inauguration of the process, commercialization requires the successful negotiation of many subsequent steps. Funding--call it "capitalization"-- is as vital for these steps as it is for the initial R&D. Depending upon the novelty of the concept and the subsequent manufacturing, distribution and marketing, the overall costs of the commercialization process described on Figure 1 are ten-to-one-hundred times the cost of the original research to demonstrate the feasibility of the concept. This commercialization cost further exacerbates the already unbalanced Federal commitments vis-a-vis acute diseases and rehabilitation.

The great majority of the three-billion-dollar annual budget of N.I.H. can be devoted to research and the underwriting of clinical trials because of the great commercial potential of the products and processes which result--all but the initial research costs being borne by the industry that manufactures and sells the product. In the case of rehabilitation, although the total subpopulation of handicapped persons is huge, the great diversity of impairment state and the specialized technological response, in combination with the already economic deprivation of the end users, results in an enormously fragmented market with very little discretionary income. Small wonder, then, that even the very modest sums spent over the past twenty years on research of new communication technologies for the handicapped and elderly have only very slowly and infrequently found their way to the marketplace as commercially viable, profit-producing, free-enterprise-market products. I can perhaps best illustrate this quandary through concrete examples drawn through my own experience.

Earlier in this conference an old friend and resolute proponent for the severely visually impaired (Safir, 1982) noted that while closed-circuit television provided access to printed material for severely visually impaired persons, it was expensive, not portable, and users had difficulty aligning the portion of the copy they wished to read with the camera, given the high magnification of the television screen monitor. Closed-circuit television (CCTV) for the visually impaired is yet another example of using widely available technology to respond to a specific handicapping need. My students and I at M.I.T. recognized that in the late 1960's when two undergraduates created one of the early demonstrations of CCTV for the visually impaired. The key was the commercial availability of TV cameras (then) below $1,000 per unit. The student design, which was subsequently replicated in small quantities under the auspices of the Massachusetts Commission for the Blind, included a convenient, easy-to-use keyboard which automatically shifted the copy to the location of interest of the viewer. In the intervening decade, two small companies have developed and produce the simpler design Dr. Safir described, but their total aggregated production thus far is about twenty thousand units. Compare this to the over one-million severely visually impaired in the U. S. Although the vital importance of such instrumentation for severely visually impaired persons has been demonstrated (Bikson, Bikson & Genensky, 1979), the small production volume, even at what some consider a high price, does not provide the competitive return on investment enjoyed by other products of broader appeal.

So despite the potential relatively few CCTV's are in circulation due to cost, non-portability, and most important, in my opinion, the virtual absence of a paramedical infra-structure who acquire knowledge of the existing technology and of successful training methods and who with patience and understanding familiarize the low-vision, usually aging person with this reading augmentation. The physician, in this case ophthamologist, is not oriented toward such rehabilitation, both because the patient is beyond therapy from his intervention and for economic considerations. This disinterest in most aspects of rehabilitation exists across virtually all medical specialties (Mann, 1978). Nor is the optician a likely candidate because of the slow product turnover and essential training and follow-up. A few low-vision clinics attempt to address this need. (Safir, 1982) Since economic considerations dominate, the broadening of health insurance payments to include the costs of rehabilitation devices and training, as natural sequelae to acute medical treatment, would create the greatest incentive to the increase of low-vision clinics.

I speak from first-hand experience with this problem. Over the past several semesters, an undergraduate at M.I.T. I have come to know has experienced deteriorating vision. Despite the best intentions of all involved, it took months to gain for him regular and convenient access to CCTV by which time he was way behind in his work.

The most poignant public statement and plea on this issue is a letter to the editor in the New England Journal of Medicine (NEJM, 1981) in which the former Director of the National Eye Institute of N.I.H. catalogs his personal experiences with encroaching blindness and his frustration in getting timely and useful advice in how to cope with the activities of daily living as his vision deteriorated.

Computerizing the preparation of Braille versions of ordinary ink print for the blind reader seemed an obvious goal when we tackled it in the late 1950's--a time of general euphoria that the new digital computer would open a new era of automatic translation between natural languages. That hope proved premature, but Braille was easier since the Braille code, being of deliberate human origin, is formally defined and zealously maintained immutable to facilitate the blind person's learning and use of the tactile format. By 1965, we had computer translation programs which, given the computer code stream for ink-print copy, would automatically produce the correctly contracted Grade II Braille code. Diffusion of the computer software was relatively easy (we made copies subject only to receiving a request and a blank magnetic tape); however, only computer-oriented people made use of the program, and thus few blind people directly benefitted. We set out to design a terminal, like a typewriter, which would accept the computer Braille code and emboss it onto paper, thus giving the blind person direct access. An undergraduate project followed by two Bachelor's theses and then a superb Master's thesis produced the M.I.T. Braillembosser; a grant supported some redesign and small-lot production, following which we mounted demonstration projects nationally and internationally putting some twenty Braillembossers in the field. Our demonstration that the computer together with an embosser could make good Braille versions of ink-print material rapidly available influenced commercial manufacture of similar devices--now by several companies here and in Europe. But again note the lengthy process of original idea, initial development, demonstration to encourage market demand, followed by commercial availability.

For a product of any novelty, this process rarely occupies less than a decade. The general public is usually oblivious of this long gestation period because companies do not publicize products until they have them available for sale. By contrast, the modest Federal funds committed to communications technology for the handicapped are in public view from the very inception of the project on through, hopefully its fulfillment as a practical, available device.

Just as the inexpensive video camera produced in quantity for the mass market made possible CCTV for the visually impaired, integrated electronic circuitry, and in particular the microprocessor, has fulfilled other concepts for Braille communication latent in student theses in the middle 1960's. Two examples will suffice: one was the notion of an attache-case-sized Braille recorder with keyboard and magnetic tape cassette on which the blind person could take notes in Braille and audio with playback via both aural output and a refreshable Braille display. Thanks to contemporary electronics, these earlier ideas are now realized in available hardware, again from both Europe and the United States. One final example of the time elapse and dependence of aids for the handicapped upon concurrent mass-volume technology would be the application of the microprocessor to the telephone switchboard to give blind operators Braille versions of information otherwise presented visually. The idea arose initially years ago when video terminals began to supplement hard copy in computer interaction. Why not give the blind person a comparable real-time, refreshable, tactile Braille display? The incorporation of the concept into the telephone switchboard awaited the commercial availability of practical microprocessors to handle the cueing and reformating of electronic information from visual to equivalent tactile Braille output. Now this commercialization process has gone full circle from idea, to laboratory demonstration, to successful extended field-test in an operating telephone company, and now acceptance by the AT&T Company as a product which will provide employment for three-to-four hundred blind telephone operators.

Describing the small company which will produce the blind-person-adapted switchborad for AT&TCo is another way of illustrating the research, development, manufacturing and marketing process. Telesensory Systems, Inc., was founded in 1970 by a professor from Stanford who had devoted the prior decade to the idea of, and research on, a portable device for converting ink-print images (detected by a miniature camera held in one hand to scan the copy) directly into enlarged, isomorphic, tactile impressions onto the index finger of the opposite hand. The research, development and hundred-unit demonstration of this optical-to-tactile converter, OPTACON, was federally funded. TSI has subsequently manufactured and marketed some eight thousand worldwide. In achieving direct access by blind persons to the printed page, this is very impressive. But economically, eight-thousand units even at an average price of say $5,000 represent only forty-million dollars of product and that distributed over ten production years. Compared to the potential return-on investment of capitalizing genetic engineering or robotics ventures, the commercialization of rehabilitation devices is relatively unattractive to the investment banker.

Another of the very few successful entrepreneural gambles in the commercialization of technology for the handicapped would be the reading machine for the blind developed and manufactured by Kurzweil Computer Products Company, Research under Federal support had been conducted for years at M.I.T. developing an optical character-recognition device and computer to read ink print automatically and then teaching the computer to articulate the copy stored in the computer. The practical application of this scheme lay fallow until a young entrepreneur formed a company, raised both public and private money, developed a unique character-reading capability and produced a practical reading machine for the blind. Some fifty or sixty of these are now in use in libraries and centers nationwide. Meanwhile, the Xerox Corporation has acquired the Kurzweil Computer Company to the financial advantage of the entrepreneur, and to the wider availability of reading machines, since Xerox plans to distribute another thirty or so to university libraries to aid blind students and staff.

Let me now abstract several general principles from these life histories of communication aids for the handicapped. The first is that the commercialization process, from original R&D through market availability, is a lengthy process, occupying at least a decade! Second, that the prototype development, manufacturing and market preparation stages are very expensive as compared to the cost of the research stage; in normal enterprises these are borne as part of the normal cost of doing business. In de novo fields, like communication aids for the handicapped and elderly, the front-end investments in development, manufacturing and marketing are very chancey; for the few devices that have been relatively successful, that financing depended both upon generous government support and fortunate philanthropy. Thirdly, the problem of product introduction and the associated cost are further exacerbated by the general economic depression of the handicapped population for whom the devices are intended. The potential beneficiaries--the handicapped--have very little discretionary money.

In this context, I am encouraged by a remark from this audience that, taken together, the over-sixty-five-year population has the highest discretionary income, save only that of the over-forty-five population. Perhaps this discretionary income will encourage the development and marketing of a wider range of more effective devices to enhance the quality of life for the elderly impaired, which will then also aid all those who suffer communication losses.

Certainly the elderly, as well as the handicapped, are becoming better organized and thereby exert more political influence. Although the current national economic climate is clouded, with the activism of the handicapped (Mann, 1978), the growing awareness of organizational strength among the elderly, and with population statistics guaranteeing an aging population, the prospects for versatile effective communications technology are better than they have ever been. Certainly the vigorous discussion of this Conference and wide dissemination of its findings will accelerate the process.

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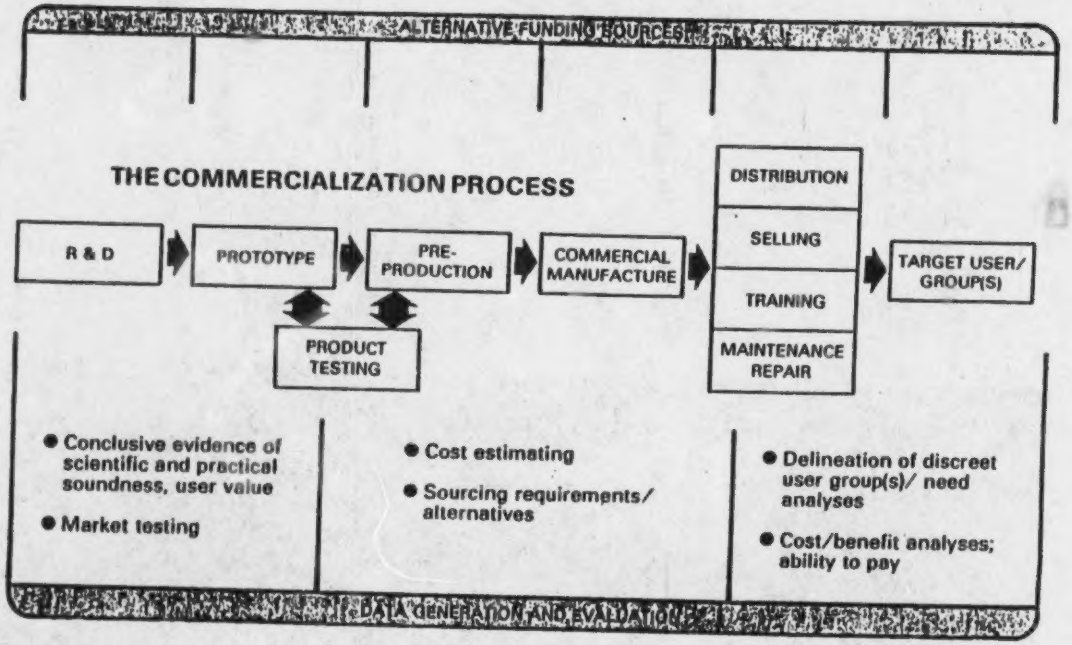
ALTERNATIVE FUNDING SOURCES
THE COMMERCIALIZATION PROCESS
R & D
PROTOTYPE
PRE-PRODUCTION
COMMERCIAL MANUFACTURE
DISTRIBUTION
SELLING
TRAINING
MAINTENANCE REPAIR
TARGET USER/ GROUP(S)
PRODUCT TESTING
● Conclusive evidence of scientific and practical soundness, user value
● Market testing
● Cost estimating
● Sourcing requirements/ alternatives
● Delineation of discreet user group(s)/ need analyses
● Cost/benefit analyses; ability to pay
DATA GENERATION AND EVALUATION

FIGURE 1

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Volume 81, Number 2, November 1978
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Technology for Human Rehabilitation

Robert W. Mann

Sophisticated applications of modern technology are beginning to open the cocoons which enclose those who are handicapped by disabling sensory or physical loss.

Disease, trauma, and congenital defects leave many humans permanently disabled. Current estimates of the number of physically handicapped in the U.S. range between 6 and 28 million persons, the uncertainty being the result of inadequate statistics and the use of many different definitions. All existing studies deplore the inadequacy of national demographic data on disablement; the universal conviction is that the cited numbers, although large, are probably understated. A useful working hypothesis for developed countries, well documented in Sweden, is that 12 per cent of the population suffers handicapping conditions of some kind — not including mental conditions.

These impairments affect virtually every body system — sensory, motor, skeletal, renal, cardiovascular, respiratory, etc.; and within each system they include a wide range of specific losses representing partial or total dysfunction. For example, losses in the motor system may result from amputation or paralysis, among the latter being such relatively modest problems as impaired use of one foot following cerebral stroke. Multiple impairment within one individual is not uncommon, as in the example of the deaf-blind. Thus the large numbers of the disabled include some overlapping disabilities in many combinations and extents of impairments.

Improved nutrition and sanitation, the use of antibiotics to control infectious diseases, and more sophisticated medical and surgical procedures have reduced infant mortality and increased life span, and these trends will surely continue. The problems of disablement have accordingly increased. Medical science can now save infants with defects which would heretofore have been fatal, and the extension of longevity has increased the incidence of those dysfunctions inevitably associated with aging. Furthermore, our technological, mobile, permissive society exposes us to many hazards. These include those of transportation and recreation as well as the results — which we are only beginning to understand — of environmental interventions involved in producing energy, food, and other industrial products. Despite significant advances in scientific knowledge and medical treatment, a decrease in the incidence of disablement is unlikely. If anything, we must expect the opposite.

The demographic dilemma, which begins with the paucity of raw medical data, is compounded by our failure to define dysfunction, impairment, and handicap. For purposes of this article, *impairment* is the consequence to an individual of a biological *dysfunction*, whether imposed by accident, therapy, or natural causes. *Handicapping* (or disability) occurs as an individual who is a victim of impairment relates to the environment and to other persons and society in the daily activities of self-care, work, and play.

Medical records clearly categorize dysfunctions, but the consequences in terms of subsequent impairments are seldom made clear: medicine as a profession is not usually involved beyond the acute or episodic phases of diagnosis and treatment. Inferring handicap from either dysfunction or impairment is even more hazardous.

For a classic example of this problem, consider the incongruence between these two estimates: the Department of Health, Education and Welfare proposes that 13 million Americans suffer a bilateral hearing loss of sufficient severity to interfere with their ability to understand speech; but the Urban Mass Transportation Administration estimates that only 350,000 people are denied access to urban mass transport because of hearing deficiencies. Such a discrepancy can be explained in part by the way in which hearing statistics are compiled, some based on objective audiometric measurements and some on behavioral questionnaires. U.M.T.A.'s lower estimate presumably also reflects the facts that not all Americans live in cities with mass transit and those who do vary in their occasion to use it; U.M.T.A. may also have made some arcane judments on *how* hearing loss affects access to bus and rail transportation.

Handicapping conditions are almost always irreversible, frequently but not necessarily chronic, and not usually life-threatening. Most handicapped persons live life spans which are close to normal. The true dimensions of handicapping, whether viewed from the individual's or society's perspective, must include this longitudinal consideration; statistics on handicapping must encompass the economic and social costs of lifetimes of impaired capability. This concept that illness should be measured in terms of its social burden is beginning to gain acceptance, and we are now seeing data for diseases showing such dimensions as potential years of life lost, days in hospital, physician office visits, lost work days, limitations of major activity, and total economic costs.

But such data are not yet used to assess the burden of disabilities and handicapping conditions. So we must rely on other ways of measuring the national social cost of handicaps: the present costs of disability payments through Social Security, pensions, and other programs are $114 billion annually; 2 million of the severely disabled are home-bound, and nearly that many are in institutions; the incomes of severely disabled people average half those of the able, and some 4 million disabled have incomes below the poverty level; whereas 30 per cent of the non-disabled national population has attended college only 9 per cent of the severely disabled has.

A New Activism for the Handicapped

But as we move to collect better demographic data and reckon more accurately the true cost of handicapping conditions, we must not let a preoccupation with numbers deflect our attention from the needs of the individual impaired person and the personal losses and tragedies involved when we fail to meet those needs. The abiding focus must be on the individual human being — on that person's own need to realize native, latent potential despite the handicap, and on society's responsibility to help.

Partly through their own efforts, the handicapped are becoming more visible, and we are witnessing more vigorous and effective action by them and on their behalf. The voice of agencies for and of the handicapped is now becoming more coherent, focused, and effective. The handicapped themselves deserve the major credit for the recent promulgation of federal regulations which mandate their "equal access" to educational institutions and employment opportunities.

Two successive Panels on Research Programs to Aid the Handicapped have emphasized the need for new technology, including applications of systems spawned by the national space program and other advanced technologies. Both these Panels have emphasized that federal expenditures in pertinent research and development have been "far too small"; in 1976, while at least $21 billion was used for rehabilitation services and outright financial assistance to the handicapped, research and development on their behalf was only $31 million — 0.15 per cent of the total, just under $3 per disabled person.

The recommendations of these Panels, of the White House Conference on Handicapped Individuals, and of a National Academy of Sciences study of Science and Technology in the Service of the Physically Handicapped are reflected in the Comprehensive Rehabilitation Services Amendments of 1978 and in other legislation before the Congress. The principal thrust of these proposals is to focus research and development on human rehabilitiation in a new institute modeled on, but not in, the National Institutes of Health, located in the proposed new Department of Education or in the current venue of the Rehabilitation Services Administration. The National Science Foundation has been directed to develop a research program in this field, and the Veterans Administration is reorganizing its program.

In conventional medical diagnosis and clinical care, the drama of the emergency, of massive intervention through surgery, and of rapid changes in patients' condition compel attention. By contrast, treatment and rehabilitation in response to chronic disabling conditions is likely to be a long, melancholy process dealing with the reality of permanent impairment while stressing the goal of maximized residual capacity. No wonder, then, that rehabilitation has been the impoverished and distant relative of clinical care. Physicians tend to choose career paths which offer the self-fulfillment of patients returned to health and mobility as well as promise of personal renumeration; rehabilitation has been the arena for paramedical people. Though it has been certified since 1968, rehabilitation medicine is practiced by only 0.44 per cent of the 344,000 physicians in the U.S., and most of these practitioners are graduates of foreign medical schools.

The New Era of Technology for the Disabled

The relationship between medicine and engineering in dealing with chronic disabling disease has been molded by this same neglect; in general, the impact of technology has not been nearly so visible or effective in rehabilitation as it has been in conventional clinical care. The only exception to this has been in the case of casualties of war. Flurries of activity in behalf of the handicapped following the Civil War and World War I in the U.S. resulted in a very rudimentary prosthesis technology, with results not extending much beyond hand-carved wood extremities. Following World War II, as part of his effort to convert the Office of Scientific Research and Development into civilian activities, Vannevar Bush encouraged high-technology firms previously engaged in such pursuits as military aircraft and radar to turn their talents towards creating prostheses and mobility aids for the blind. But oversophisticated technology and primitive understanding of human need yielded essentially no useful outcome.

The gulf separating engineering from the problems of the handicapped persisted for at least another decade. The modest but significant armamentorium of devices which now give handicapped individuals opportunities for more normal life experiences and for participation in society stem only from work arising in the late 1950s and the early 1960s.

Consider, for example, our slow progress through three stages in utilizing the technologies of digital computation and optical character recognition, leading to a revolution in creating printed material for the blind. Prior to the 1950s braille, adapted from a tactual code originally devised for night-time direction of military artillery, required sighted translators and cumbersome, slow embossing processes. In the 1960s this translation process was automated: printed matter can now be scanned and rendered automatically into braille, greatly reducing the time required for translation and thus giving the blind far more timely access to printed material in braille form. But braille itself is cumbersome, and a more significant recent development is one which reduces dependence on its use by giving direct access to the printed page to men and women with severe visual impairment. This is the very successful OPTACON, a portable device the size of a cassette recorder; when the blind user scans printed material with a tiny camera employing solid-state optoelectronics in one hand, a vibration characteristic of each printed character encountered by the camera is felt against the finger of the opposite hand inserted into the device. With training, reading speeds of up to 100 words a minute are possible.

Still more efficient means of information acquisition for the blind are now being developed to capitalize on the efficiency of speech itself. Optical character recognition devices are now being coupled with computer-based synthetic speech generators to make possible true reading machines for blind people: words are scanned automatically, and sounds characteristic of the letters and groups of letters are automatically generated as synthetic speech.

A similar development is leading to ever-more-effective technology applied to problems of the disabled. The blind traveller used to depend exclusively upon a long cane, a guide dog, or a sighted human to assure that his or her next step would be a safe one. Now, thanks to the tenacity of several researchers studying ultrasonic electronic means of exploring the environment, hundreds of the blind world-wide are being given information which extends their mobility strategy to their next several or even a dozen steps.

The PATHSOUNDER, worn about the neck like a camera, acts as an ultrasonic radar: it remains silent in the absence of echoes from would-be obstacles, indicating a clear path. But when an obstacle reflects the PATHSOUNDER's pulse, an audible or vibratory warning signals the presence of the obstacle and indicates its distance. The same principle has now been further exploited in SONIC GUIDE, in which two ultrasonic elements mounted to the left and right of the nose bridge on an eyeglass frame. The ultrasonic echo of an object is presented to both ears but is loudest in that ear nearest the object, and the blind person can invoke his or her inherent binaural sound-localization ability obtain directional information about the reflecting hazard. Range is coded into the frequency of the perceived signal, and even the reflection characteristics of each object are discernable as the presence or absence of complex overtones on the primary range signal. For example, a planar reflector such as a plate glass window provides a pure tone, and diffuse reflectors such as trees, fences, etc., result in characteristic, identifiable sounds. Thus the blind user is offered a rich, audible orchestration of the spatial surround.

Help for those handicapped by impaired hearing became really practical when solid-state electronics made possible very small appliances with low power consumption. Now there are countless forms of small hearing aids for those who require amplified sound. For the profoundly deaf, devices which stimulate the skin with either mechanical or electrical vibrations can provide some auditory input.

Interesting experiments are being conducted on hearing-deprived infants and children who, as a result of their loss, never acquire natural speech. The research problem is to devise some spatial-temporal tactual display which can communicate speech patterns. Although this goal remains to be achieved, our growing capability in using computers to organize and process data for systematic human interaction and to replicate human communication systems will undoubtedly lead to important future developments.

Building Feedback into Prostheses

Computer-based simulations of human systems have already proved themselves in research on prostheses for upper and lower extremities following amputation. The feasibility of using minute electrical signals from remnant muscles in the amputee's stump to control an electromechanical elbow was first demonstrated in the BOSTON ARM; the concept was proved in advance of development by computer simulation. The research, and later the successful application of the prosthesis itself, demonstrated that in all cases, however fragmented or atrophied they are, the relevant muscular fragments are still under control of the brain. The signals they provide are adequate, with electronic magnification, to connect the brain's intent with the machine's response. Thus the amputee's control of his elbow prosthesis is "natural"; research versions of the device include detectors and feedback circuits which inform the amputee of the angle of his elbow and heighten his sense of the load in his artificial hand.

The BOSTON ARM replicates only one of the movement capabilities lost by an above-elbow amputee. More complex upper-extremity prostheses which replicate rotation of the wrist and of the arm itself about the axis of the upper arm, as well as elbow flexion, have been developed and are now under evaluation. The problem is rendered complex by several factors — the low total weight which the amputee can tolerate, the limitation of volume — for cosmetic reasons — to that of the natural limb, and the complexity of the motions to be replicated. These make necessary extremely sophisticated and compact electromechanical designs and efficient energy storage and utilization.

But by far the most difficult problem is devising a human machine interface which can detect authentically the human's intent and reflect this accurately in the machine response. For the single-axis BOSTON ARM elbow, detecting the activity of a single pair of antagonistic muscles is adequate. Control of the three-axis UTAH ARM, the more complete upper-extremity prosthesis, requires detection of myoelectric activity at ten locations in the shoulder, back, and chest overlying the muscle systems which collaborate in the several motions. Then these muscle signals must be played into a computer model of the natural musculature to yield appropriate commands to motors which control wrist, elbow, and arm motions.

The SWEDISH HAND is a forearm-and-hand prosthesis with a similar control strategy to provide wrist rotation and flexion along with several modes of finger flexion and thumb rotation. In this case, some of the musculature needed to control the hand is missing, so a "learning" process is required of both amputee and prosthesis. The residual musculature of the amputee's forearm is first made to interact directly with a pattern-recognition program in a free-standing computer; in turn, the computer output drives the several actuators of the wrist and hand. With the prosthesis in view of the amputee, he is asked to attempt patterns of muscular activity appropriate for a motion — say wrist flexion or rotation. His observation of the prosthesis response reinforces his own appropriate muscular activity. When the proper combinations of electrode locations and muscular activities are identified, the pattern-recognition design is transferred from the computer to a physical electronics package for incorporation into the prosthesis.

Rehabilitation following paralysis, hemiplegia, and paraplegia (loss of the use of two extremities), and quadraplegia poses somewhat different problems from that following amputation, since in these cases the affected limbs are still intact, albeit partially or wholly immobilized and probably uncontrollable. A common solution is the use of an external supporting orthotic frame with a powered actuator. Functional Electrical Stimulation (F.E.S.) of the otherwise useless muscular tissue, a strategy which — like those previously discussed — capitalizes on the residual nervous system, is a less cumbersome and very useful alternative.

Electrical impulses applied to electrodes on the skin over the point where a nerve enters a muscle, or needle electrodes actually in contact with the muscle, are used to cause muscle contractions somewhat similar to those originally invoked by the physiological nerve signals. When a desired motion is not demanding, as in residual "drop foot" following hemiplegia, F.E.S. can be useful indeed, providing the stroke victim with improved gait. A stimulator worn on the patient's belt receives its signal from a heel-switch transmitter and broadcasts a tiny impulse to an implanted receiver connected to an electrode on the peroneal nerve, causing muscle contraction and foot dorsiflexion. More complex versions of this approach, which will stimulate major muscles around the hip in an appropriate sequence, are being explored as an approach for restoring walking to the paraplegic. The problems to be resolved are substantial. Even massive stimulation of muscle cannot produce maximum contraction and leads to early fatigue; the use of several electrodes in each muscle, each stimulated in sequence, can improve muscle performance. At the same time, the relationships between the several muscles involved in walking must be preserved, and the synergistic cooperation of the many muscle groups around the several joints must be achieved. Beyond this, the problems of stability must be successfully addressed if the patient is to be able to walk safely without assistance.

Engineering in the Medical Environment

Two issues are at stake in bringing effective prosthesis to more and new classes of users. One represents the unfinished business of research and development — the basic need for new technology. The other is the problem of how to bring successful prototype prostheses from laboratory curiosities into practical, commercial devices available at acceptable prices. This represents a major problem in technology transfer which must be recognized and solved. *Ad hoc* solutions are sometimes successful; examples include computer-translation programs for braille disseminated through commercial computer networks and the development and manufacture of the BOSTON ARM by an insurance company.

Fortunately, the field of rehabilitation and prosthetic devices is beginning to attract serious entrepreneurs who are establishing responsible enterprises devoted to making a fair profit through the manufacture and distribution of aids for the handicapped. The most notable of these to date is Telesensory Systems, Inc., producers of the OPTACON reading machine and a SPEECH PLUS "talking calculator."

Other companies are making equally important contributions by creating employment opportunities for the handicapped — for example, by installing nonvisual switchboard positions for blind telephone operators using braille and/or spoken displays instead of flashing buttons and visual alphanumerics. But at best handicapped people are likely to be under severe economic constraints; despite improving employment opportunities, few are able to buy expensive prostheses and then invest time and effort in learning to use them. Means must be found to partially subsidize the production of useful rehabilitation products and/or to help those who need such products acquire them; either or both should become an accepted part of health care costs. Health insurance payments should be broadened to include the cost of rehabilitation devices and of the training necessary for their use, both being natural sequels to medical diagnosis and treatment.

Another requirement for optimum rehabilitation is close collaboration between physician and engineer in searching for the optimum combination of treatment and prostheses which will maximize recovery of the individual patient's functions. A few examples will suffice to make clear the importance of this "team" concept. In fitting an artificial limb (prosthesis) to an amputee, the knowledge and skills of the orthopedic surgeon in physical medicine and rehabilitation complement the engineer's knowledge of biomechanics, kinematics, materials, and fabrication. Or when severe quadraplegia or other neuromuscular defects deprive an otherwise intelligent person of the ability to communicate verbally, then a communications engineer and an occupational therapist can help set rational priorities among the several different needs. In countless cases such as these, the participation of a rehabilitation engineer with the medical and paramedical staff in the various clinics — amputation, scoliosis, hemiplegia, etc. — provides valuable perspectives on the patient's difficulties. Sometimes this leads to an improved diagnosis, and almost invariably it leads to a more satisfactory clinical and rehabilitative solution. Current medical knowledge and contemporary technology can thus be brought together so that each reinforces the other.

Having said this, however, I must note that physicians are minimally, or not at all, involved in large areas of rehabilitation. These are cases where the patient's condition has been stabilized by a physician's diagnosis and treatment, when subsequent rehabilitation is placed in the hands of physical and occupational therapists and mobility, orientation, and communication specialists. The engineer's role is then dominant during the conception, realization, and adaptation of appropriate prostheses. (But sometimes these steps are made almost too simple, and engineers are hardly involved at all; most deaf people obtain rehabilitation assistance, if at all, from an audiologist or, more likely, a hearing aid salesman.)

Whenever it occurs, the involvement of an engineer in close synergistic relationship with a physician or a paramedical worker in a health-care facility can and does lead to the identification of research opportunities which might not otherwise be apparent. Thus the interaction of medicine and engineering is not limited to direct patient services. The intellectual approach of the engineer, based on his understanding of the physical sciences and mathematics, is uniquely valuable in collaboration with the biological, anatomical, and behavioral knowledge of the physician and even of the paramedical specialist. The result is invariably new concepts and directions for research in rehabilitation.

Such situations typically lead to emphasis on patient-centered adaptations of existing devices or concepts. These are obviously important and valuable, but longer-range, more generalized research must be undertaken if basic changes in prostheses and rehabilitation systems are to be made in the future. The OPTACON and cybernetically-linked replacement limbs such as the BOSTON ARM represent the fruits of such basic research. Unfortunately such generalized studies bringing medicine and engineering together have not in the past enjoyed very high priorities in the planning or funding of rehabilitation work.

One reason for the inadequate support of fundamental rehabilitation research is its enormously broad interdisciplinary range. Consider, for example, the very persistent need for cross-sensory modality transfer following the loss of one or another of a human's sensory capabilities. The blind can only hear or feel; the deaf can only see or feel; the amputee can no longer sense movement in the missing limb. In all such cases, the lost spatial, communicative, or kinesthetic sense can only be transmitted through one of the remaining senses. In the case of blindness, for example, the real rehabilitation research question is: How can spatial information normally perceived through a three-dimensional, color-sensitive, high-resolution system of eye and brain be restructured so as to be optimally presented to the auditory mechanism or through the limited dynamic range of the skin sense? Or consider another important dimension of this interrelationship of the communicative sense: How does human development relate to rehabilitation? We know that the congenitally deaf child is at great disadvantage because hearing deprivation robs him of the natural acquisition of language. Could special visual and/or tactual information imparted to that child during the years when language skills would naturally develop accelerate the child's use of language or make it more adequate?

Many other examples of what I call basic rehabilitation research needs could be cited, among them: the need to detect and interpret nervous system activity at many additional points and in other ways to control replacement limbs supplied to amputees; the need to selectively stimulate physiological control centers to reanimate the immobilized; or the need (an even more ambitious, longer-term hope) to stimulate the brain to by-pass deficient sensory organs and achieve substitutes for normal audition, for example, or vision.

A Knee That Meets Its Wearer's Needs

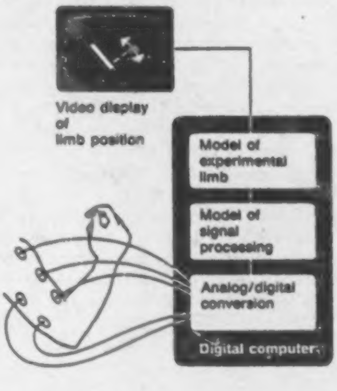
Let me close this article by describing what I believe to be the area of premier potential in such fundamental research on motor and sensory prostheses — the study of man-machine systems.

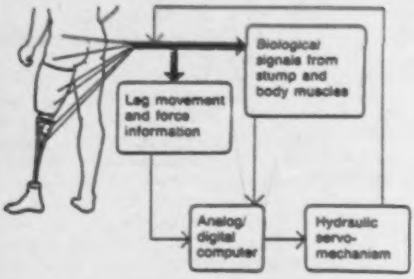
The underlying question in every case of prosthetics research is how best to relate the residual capacity of a human and the replacement capacity of a machine so that the machine becomes as nearly as possible a natural extension of the human. The machine must be under the human's neural control, and it must be capable of transducing back into the human's sensory system appropriate information about itself and the environment. So many questions must be asked and so many variables optimized in such systems that their study must, in my view, be conducted with computer-based simulations which involve potential prostheses and human users. In this way many

Matching Humans and Prostheses by Computers

One of the underlying problems in prosthesis research is how best to relate the residual capacity of the human to a machine so that the machine becomes a natural extension of the human, under his control, responding much as the missing limb would have, and capable of transducing back into his sensory system appropriate information about the environment and the machine's place in it. So many questions must be resolved — and so many variables optimized — in research on such devices that it proves desirable and even necessary to study the relationship between man and hypothesized prosthetic aids in a computer-based simulation. With such a system many signal processing combinations and many different limb characteristics can be evaluated against both objective and subjective criteria as the human interacts through the computer with a generalized prosthesis. The computer simulates important aspects of possible future devices, reducing the need for hardware in the exploratory phase. This design concept has been successfully used in the development of two prostheses at M.I.T., and its use continues in studies of new devices and systems.

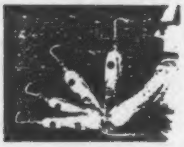
The BOSTON ARM *(below)* was the first device developed through such a computer-based, man-machine analysis. It was in fact the first practical demonstration that biological signals emanating from the brain, intended for a now-amputated limb, can be detected in the stump and used to control an artificial elbow in a natural manner with virtually no training. The diagram shows the man-interactive simulation system used in the initial research. Data from electrodes over the remnant muscles in the upper arm are converted into digital signals; the computer's video display shows the limb's




Biological signals from stump and body muscles
Leg movement and force information
Analog/ digital computer
Hydraulic servo-mechanism

response for various different signal processing and device configurations. When the optimal control strategies were identified with this simulation system they were adopted for the first BOSTON ARM prototype.

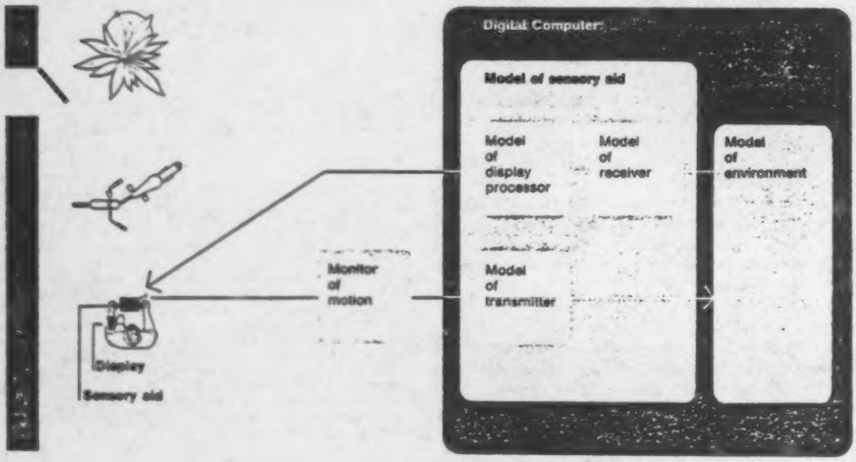
The same concept is now being used in developing a naturally-controlled adaptive knee joint *(above)* for lower-extremity prosthesis. A high-performance electrohydraulic servomechanism at the arifical knee permits passive or active knee-joint movement under the control of signals received from the biological sources in the amputee and physical transducers in the prosthesis, the two being combined in a computer. The goal is to achieve such a combination of biological and physical control that the characteristics of the knee joint will be variable in accordance with the user's needs, adapting the knee's movement to different cadences and to the demands of ramps and even stairs, providing flexion during stance, and perhaps even responding to such unexpected events as tripping. A future wearable system might have in storage in a microprocessor information on knee torque versus angle profiles for each of a number of such different modes of activity. An intent-recognition scheme drawing signals from the amputee's stump would select the appropriate mode with little or no overt effort on the part of the user, and a built-in electronic system would produce the knee profile appropriate to the user's next movements.



Radar-like systems utilizing ultrasound are now available to extend the mobility of the blind, augmenting their long canes and guide dogs. But the repertoire of information which such an ultrasonic radar can obtain is far greater than our capability for transmitting it to the blind traveller; and now the same concepts for computer-simulation are being applied to the study of sensory aids which would present more information in more useful formats to blind users.

A digital computer system compares the movement of a human subject with a map of an environment through which the human is moving, in this case *(below)* a space containing a bicycle and a tree. The reflection "signatures" from these two hazards are very different — the tree is a soft, unfocussed obstacle, the bicycle a sharp, narrow, linear one; the tree is fixed in position, the bicycle is probably moving; the bicycle is just ahead, the tree further away, off to the right. With this information the computer can produce commands for various forms of sensory input which are telemetered to a display on the subject. With a system such as this a much richer variety of acoustic and sensory cues can be explored and evaluated than could ever be achieved by designing, building, and testing specific concepts one by one.

And when the optimum display systems are determined, the specific functions needed to provide them can be built into a miniaturized unit which can become part of a portable mobility device.



variations of signal processing and limb characteristics can be evaluated, against both objective and subjective criteria, as the human interacts with a generalized limb; and all this can be done before a commitment is made to any particular hardware.

The group in our laboratory is currently using this strategy in exploring several concepts for biologically-controlled lower-extremity prostheses, in particular an adaptive knee joint.

The natural knee exhibits many different patterns of muscular activity during walking; movement and rhythm on level terrain are very different from those while going up a ramp or down a stairway, for examples. An unexpected event, such as tripping, elicits yet another mode of behavior. A goal of our research is to give an artificial knee a repertoire of trajectories to emulate these natural functions appropriate for each mode of activity. We employ a high-performance electrohydraulic servomechanism in the prosthetic knee joint to permit passive or active movement on the basis of signals received from the user's body combined in the laboratory computer with those received from the artificial leg below the knee. Such an arrangement permits changing the characteristics of the knee joint almost continuously, even during a single step, just as man himself does — adapting the period of the leg to different cadences or providing flexion during stance to reduce the vertical movement of the body's center of gravity, thus reducing the metabolic cost of walking.

To switch from mode to mode, a scheme to recognize biological intent, in principle if not in detail similar to those previously decribed in the UTAH ARM and the SWEDISH HAND, observes the activities of muscles above the knee. This biological data combined with information transduced from the artificial leg produces in the computer a distinguishing characteristic of the mode change, thus conveying the amputee's intent to the knee mechanism without any overt effort on his part. A future wearable knee system might then have in storage, in a microprocessor, the various knee motion profiles for each activity; an on-board electronic system would define the knee motion appropriate for a particular situation.

This concept for prostheses which interact with their users to automatically simulate normal function should apply equally well to devices for improving the mobility of humans deprived of normal sensory input. The PATHSOUNDER and SONIC GUIDE are examples, the first producing deliberately simple cues, the latter a richer representation of the environmental surround. Both devices have enthusiastic users, but it is clear that an enormous range of other ways to simulate the auditory and tactual senses need to be explored in order to produce even more effective surrogates for lost vision.

To be authentic, such a simulation system would have to permit free mobility of the human through a space cluttered with obstacles by providing many forms of natural nonvisual stimuli — echoes, air drafts, odors, etc. — to the traveller. An ideal computer-based system would make possible a systematic, yet objective, search of the user's solution space, comparing the physical characteristics it detects with models in its memory and providing to the user a wide variety of tactile or auditory cues, or combinations thereof. Much of such a system for providing a rich repertoire of environmental information is now operational in our laboratory.

The history of contemporary technology in prostheses for the handicapped is a scant two decades old. Very significant beginnings have been made in access to print and enhanced mobility for the blind and in prostheses which adequately reflect the cognitive intent of the human. Yet what has been accomplished thus far deals with but a small portion of the enormous cocoon which encloses the handicapped to limit and frustrate their aspirations.

Our response to this important human need compares most unfavorably, in both sophistication and comprehensiveness, with our scientific advances in medicine and our technological progress in space or weaponry. But there are promising signs that as a society we are beginning to hear and respond to the legitimate needs of the handicapped. With ever-more-sophisiticated design and guided by growing knowledge of physiology, communications, and the man-machine interface, we are beginning to bring to handicapped people the near-normal human capabilities they need and deserve.

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Robert W. Mann is Whitaker Professor of Biomedical Engineering in the M.I.T. Department of Mechanical Engineering, and for the past decade he has been a principal architect of the application of engineering to meet the needs of the handicapped. His career began in the field of engineering design with undergraduate (S.B. 1950) and graduate (S.M. 1951, Sc. D. 1957) degrees in mechanical engineering at the Institute, where he first specialized in dynamic analysis and control and computer-aided design. He now brings this interest in dynamic systems and computer control to research on human rehabilitation, degenerative arthritis, and biomaterials.

Mr. DYMALLY. Dr. Mann, we have to take a recess; we will be right back.

[Recess taken.]

Mr. DYMALLY. Let's begin some questions with the panel. Then when Mrs. Heckler comes we will call Dr. Slaughter back. She is on her way.

Dr. Mann, did I get the impression you are not too happy with the cuts in the physically handicapped program?

Dr. MANN. I am very distressed by them.

Mr. DYMALLY. Are you then more supportive of the old program rather than the new approach?

Dr. MANN. Yes, I am.

Mr. DYMALLY. Let me just interrupt here and ask Dr. Slaughter and Dr. Langenberg to come back to the table. In Mrs. Heckler's absence I suggested that women and minorities is her special interest and I wanted to be sure she gave it adequate protection. Would you proceed, Mrs. Heckler?

Mrs. HECKLER. Thank you very much, Mr. Chairman. I want to thank you for your special consideration and I want to thank the witnesses. I was unavoidably absent earlier this morning and really appreciate the opportunity to pursue the issues that are naturally of special interest and concern to me. I said to my colleague here that it is fortunate that we are both here to fight for our rights. It is a positive opportunity in our congressional experience to both be on the same subcommittee.

Dr. Slaughter, we have discussed the subject of women and minorities so often, publicly, privately, in the committee, et cetera. Nonetheless I think there are questions that have to be raised. We have heard many witnesses both here in Washington, in Boston at our hearings, and in Pittsburgh who have testified to the cost effectivness of the women's programs.

Most of the NSF programs we have heard about have paid off in the sense of having the beneficiary earn more in the private sector within a very short span of time, and thereupon return more to the Federal Treasury than the actual cost of the programs. Consequently, the salary increases develop special increases for Uncle Sam.

Under these circumstances, I wondered how successful you have found the programs and how much funding you think could be absorbed into the targeted programs for women.

Dr. SLAUGHTER. Mrs. Heckler, it is interesting to think of these programs increasing the salaries of the women who have participated—a byproduct. That is perhaps a useful way of examining the programs. However, as you know, NSF's rationale for the programs is somewhat different. I would measure the success of the activity more by the increase in access and the increase in the quality participation of women in science and technology. That kind of success contributes to a national need for improved productivity, improved research, improved effectiveness of the total scientific and technological enterprise.

I would say that the effectiveness of the programs may be indicated in several ways. One, an independent evaluation of the reentry program for women showed that to be effective. The program met the goal of providing opportunities for women who had been in a scientific or technological field, but who had not continued for a variety of reasons to become involved again.

A workshop program has not undergone the same kind of evaluation, but judging from the interest of the participants themselves to continue the activities, it must be considered a great success. Many of the participants are looking for other ways of supporting this kind of program because they believe the workshops were successful.

Certainly, additional funding could benefit these programs. I would, however, hesitate to say that additional funds should be applied specifically to the programs we are identifying in fiscal year 1983. Perhaps some part of the funding could be used to make them more effective. But it would make more sense for the community of persons involved, the committee on equal opportunities and others, to examine the real opportunities and the real needs of programs for women and programs for minorities. If additional funds were available, they might be used in a more effective manner. Within the limits of the available resources, the things NSF is doing represent an optimum I feel good about that part of the program.

Mrs. HECKLER. Unfortunately, I get the impression that they represent a minimum, really.

Dr. SLAUGHTER. Within the constrained resources, I think we are doing the right things. I agree more could be done and more funding would allow to do so. I feel confident that among the activities we are pursuing, we have chosen the right ones for the resources available to NSF in fiscal year 1983.

Mrs. HECKLER. Well, then, obviously you are saying that the national research opportunity grants were not of that level of priority, nor was the science education directorate.

Dr. SLAUGHTER. No, the situation in the science and engineering education directorate is different. An entire group of programs was unfortunately placed in science education. When the science and engineering program was severely reduced, many activities oriented toward the concerns of minorities, women, and the handicapped, were included in the reduction.

We have attempted to focus within the NSF research programs some attention to these areas because we believe they should not be considered in an aggregate of other programs in science and engineering education. Simply because these programs happened to be placed in the same directorate, they were eliminated. There is no question within the Foundation or within the administration that it is important to address these matters.

Mrs. HECKLER. I am particularly interested in the national research opportunity grants. This program was never implemented. Are the functions of that particular program going to be covered anywhere else in the budget for NSF?

Dr. SLAUGHTER. We had to move fairly rapidly in putting together the program for women in fiscal year 1983. We considered several problems associated with the research opportunity grants, including how such a program could be put into place and managed in time for the fiscal year 1983 budget.

We decided in favor of an activity to address at least one of the needs raised by the women's subcommittee of the Equal Opportunities in Science and Technology Committee. It was much easier, to be perfectly frank, to put into place the visiting professorship for women program and to ask the committee to assist us in formulating something like opportunity grant at a later stage.

Mrs. **Heckler**. Do you expect to establish a mandate whereby that function will be pursued?

Dr. **Slaughter**. I do not know that I would establish a mandate. I think I will get the attention from the women's subcommittee—the chairman is here and could express the subcommittee view. I have already received from the subcommittee some strong recommendations, and I intend to work with them and the committee at its April 6 and 7 meeting to determine how we can put into place some action in that direction.

Mrs. **Heckler**. Well, I think that the context in which the whole issue should be considered is actually the one that you expressed. That is the availability of a very substantial human resource for the solution of very major national problems in productivity and in the development of highly qualified technical personnel to keep our high technology energy fueled.

Now you and I both participated in the National Governors Conference task force hearing on high technology, where I made the point that the resources of women should not be overlooked by the private sector. I want to say that after that, at the conclusion of that meeting, I received many supportive comments from women who were either there in a staff capacity or spectators. I received no comments whatsoever from the industry leaders who were present. I think the point that I am making is the one that has just been raised by Dr. Pfafflin, that is, the issue of Government-industry dialog.

It seems that between the whole high technology industry that has such dire educational needs particularly at this time, and the NSF which has the major governmental leadership role—there seems to be very little dialog on the question of the human resources of minorities, women, and the handicapped. There is no dialog at all. I do not see any consciousness in the private sector. I wonder if you have observed this and what you can do about this?

The budget is very important, but if we are speaking only to each other, then we are not reaching out to our broadest audience.

Dr. **Slaughter**. Mrs. Heckler, I was most impressed with your comments at the conference. You would be amused, I think, to know that just a few days later I spent an hour with a group of industrial leaders, about 40 to 50 of them, who had invited me to talk about the major issues faced by the National Science Foundation.

I said publicly to them it was interesting, looking around the room, that none of them looked like either you or me, and that this in fact was a key element of the problem. It is difficult, perhaps, to inspire a group of persons who have not felt a need in the past. However, it is happening; it is occurring. It is occurring because you speak out, and people understand it is a matter of concern. It is occurring because Congressman Dymally takes a lead role. And I hope in some small way that my speaking on the issue has an impact.

The impact is now going to be multiplied because I feel that my colleagues at the National Science Foundation, on their own, are speaking out on this matter. Dr. Langenberg is speaking out. When that begins to occur, that is when we begin to see the synergism we are all looking for to make a meaningful assault on the problem.

Mrs. HECKLER. I do applaud the fact that you speak out. I respect that. On many, many occasions I have heard you, and I also have received reports of what you have done. Nevertheless, I want to know what the feedback is because I sensed almost no awareness at that meeting, and here we had some of the giants in the high technology industry present.

Dr. SLAUGHTER. Let me mention a program, not because I mandated it—to use a word you used earlier—but because an NSF division director saw an opportunity to involve industry in a project that could have far-reaching consequences.

A program in the STIA directorate is concerned with Government-industry interactions. It is intended to involve industrial organizations in problems related to greater minority participation. Grants are available for industry-university cooperative activities with an emphasis on industrial responsibility to involve more minority people in industrial activities.

We are encouraging industry to work with high schools with large minority enrollments, getting students to look at what happens in industrial organizations, using the plant as part of an educational process as much as producing a product. The program was initiated by an NSF division director because he saw an opportunity for the Foundation to be seen, to be heard, and to take a leadership role.

The feedback from industry has been positive, small admittedly, but a start. I hope we can see it institutionalized in a small way. I will be happy to send you some material in greater detail.

Mrs. HECKLER. I would be interested in that. Furthermore, I would be interested in the ways that NSF in a leadership role can confront the barriers that women face in the academic world. Obviously we have heard testimony on that today in depth, and that remains a constant problem. They are not on the tenure track. What can NSF do? How can changes be accomplished there?

Dr. SLAUGHTER. Well, we believe that the visiting professorships for women program provides support to a woman researcher, allowing her to establish a more active research program at a university, and to interact with male colleagues for access to greater career opportunities. We hope the mutual experience of the woman researcher and the university may provide her greater access to a career in a scientific discipline in the university.

Breaking into the physical sciences in universities now is difficult for anyone, except in a few narrow disciplines, simply because of declining enrollments and large numbers of tenured faculty. It is difficult for anyone at the moment who wishes to pursue an academic career, except for a few fields in engineering and in the physical sciences.

Certainly it is going to be more difficult if we do not put into place some mechanisms by which women and minorities can be aware of and in contact with university administrators and their peers in the sciences. We hope the visiting professorships for women program will be a small start in solving the problem you mentioned.

Mrs. HECKLER. I think the dialog with the faculty and presidents of universities could also be the result of a changing awareness.

Frankly, I really would like to go back to the national research opportunity grants proposal. It obviously has been dropped by the administration. Do you support this?

Dr. SLAUGHTER. No, I do not support the idea that the research opportunity grants should be dropped, Mrs. Heckler. The program happened to be in the wrong part of the Foundation's budget at the time, and putting it into place for fiscal year 1983 was not feasible. I believe this kind of program makes a lot of sense. What we need to do is to determine a way in which we can put it in place within the fiscal constraints. It is that simple.

Dr. LANGENBERG. Mrs. Heckler, if I might supplement that——

Mrs. HECKLER. Yes, certainly.

Dr. LANGENBERG. I was rather strongly involved in the process of creating the detailed program design for the national research opportunity grants, following the specifications of the fiscal year 1981 authorization, Title B. When the funding for that program was deleted in the March revision of the budget, along with funding for all new starts in what was formerly called the cross-directorate program, we had to shelve the opportunity grants program.

The program remains as a possibility for the future but I might add that in discussing the proposed program—the details of its design, how it would be carried out, under what circumstances, what constraints, and what requirements—it developed that there is a good deal less consensus among women scientists about exactly how best to make it work.

Frankly, when an opportunity arose to reinstitute and to reenter a program focused on women and research, the visiting professorships for women program was a more obvious candidate than the national research opportunity grants, all concerned agreed on how we ought to go about it. We need a little more design work on the other program.

Mrs. HECKLER. Well, why do you expect this unanimity among women when no one ever expects it among men? [Laughter.]

I mean, really, must we all agree? Do you think that all women agree on anything? Isn't that a rather unrealistic human standard? Do you think all blacks or all Chicanos would agree if you asked them about the design of a program?

Dr. LANGENBERG. No, I don't think so. We have, perhaps, an over-abundance of good ideas about exactly how that program should work. We would like to be a little more secure in our understanding that we are doing the optimum before we embark. The program is not a dead issue by any means.

Mrs. HECKLER. Well, I am glad to hear that because I really do sense and have always sensed in your testimony the good will that you exude on this subject, and yet I am very impatient with the results. I really think that it is fine to have your heart in the right place but if we do not have the programs in place, we are not going to achieve the objectives. In other words, the right feelings are not going to be enough.

I feel we are frightfully behind. We had to fight very hard to save the women and minorities program last year. Now we know that on the one hand we have the technology problems, the personnel problems, the academic training needs, the productivity lag between the United States and Japan, all these enormous difficulties facing the industry and the jobs affected by it, and here we have an enormous resource in the population of women and the minorities and we do not really seem to be making the right linkages. I would hope that there would be a development of a sense of urgency within the NSF on this subject, not only in terms of the national research opportunity grants program, but on the whole picture. I think we are dealing with fringe issues and not centrally attacking what could be a major resolution of national problems.

Dr. **Slaughter**. Mrs. Heckler, your points are good, and we can cover them. Let me remind you, though, we believe it is equally important, perhaps more important than we recognize, for the infrastructure of the Foundation to recognize women and minorities programs as integral parts of the total Foundation effort. We have spent at least as much time, perhaps more time in developing that recognition so that the action I mentioned in the STIA directorate can occur spontaneously. I will be most happy when that sort of action occurs in a sizable number of NSF divisions. I will feel that we will be doing much more there than we can do with a single-purpose program.

Mrs. **Heckler**. Well, I do appreciate the support that you feel for the programs and I do think I would like to see more of an extension of the promises made in a practical sense, in terms of budget and emphasis. I also want to say, Dr. Slaughter, that I think you have a unique capacity for leadership. In that unique position, you have more of an opportunity for impact that the most brilliant predecessor.

I do feel that at this critical time, in terms of our national and international needs, the impact you can make for women and minorities should be a part of the message to the affected industries and to the academic community in a position of priority because it is so essential, and also because you can deliver the message so well in the unique role that you play. Obviously you are confronted by many pressures, and I understand that. I would really hope that you understand that leadership capacity, as I see it, in all the forums in which I have participated with you, and use it internally as well. We are told we are involved with an industrial revolution. Well, let the industrial revolution have an equal opportunity component so that we can also have a fair society.

Mr. **Dymally**. Thank you.

Now we will return to Dr. Pfafflin, Dr. Merideth, and Dr. Mann.

Dr. Mann, would you proceed with your response to my question regarding the role of the handicapped program in the NSF?

Dr. **Mann**. I think it is vital that the program continue to be uniquely identified. In general terms, in Candide's "best of all possible worlds," the world would be homogenous, and everything essentially would not have to be focused on in order to give it proper attention. However, we are not in Candide's world and we are not going to get there unless we try very hard to focus on where our problems are.

The address of handicapped needs through research, essentially, is a target that has been not adequately addressed historically and it is not being adequately addressed now. In that larger framework, the NSF program played a very significant role. To the extent that it was terminated, that role will disappear. It was the window on research, the potential for research support for really very bright ideas, very radical ideas, and long-range research ideas for aiding the physically handicapped, and I might say having largely their origins in engineering and physical scientists' minds and from university faculty of that sort.

Those individuals now have very limited access to even the modest funds that are available through the National Institute of Handicapped Research and the Veterans' Administration because of the clinical shorter range focus of those two organizations, which is perfectly appropriate for them provided it is supplemented by a component such as NSF has provided.

Now to go back to Dr. Slaughter's posture that all will be well because this will be factored into. That is not my experience and it is not my experience at any level, essentially, in terms of the vigor with which we each pursue our disciplinary interests. The very structure of the engineering directorate in the National Science Foundation is along traditional engineering departmental lines.

Handicapped research is cross-disciplinary. It just absolutely eschews any kind of a pigeonhole of being applied mechanics, or fluid mechanics, or artificial intelligence, or flow theory, or whatever else it might be. However, that is essentially the structure of the National Science Foundation and so proposals that come in to the National Science Foundation understandably have higher credibility and get a warmer reception if they are more discipline oriented. I might say that the peer reviewers, which in the NSF approach are selected by the manager, are selected, by and large, from categories of peer reviewers for that discipline which this manager is convinced will provide the most rigorous scientific review of the proposal. That is exactly what should happen. However, they will not include, or have a low probability of including, people who have an understanding of the cross disciplinary, complex, handicapped origin, essentially, of the proposal.

Mr. DYMALLY. I am happy that Mrs. Heckler is here for this dialog, first because you are from Massachusetts but last year she led the fight to restore the women in minorities program. My question to you is, if such a fight is led again by someone on the committee, would you be able to come back and support such an effort. Mrs. Heckler?

Mrs. HECKLER. Mr. Chairman, are we questioning the whole panel?

Mr. DYMALLY. Yes, indeed.

Mrs. HECKLER. I want to say, Dr. Mann, that I am very impressed with your testimony. You are a very eloquent spokesman for the interests that you serve. They are very rarely addressed so it is useful to have this brought up. I also am pleased, since I have served on the Veterans Committee since I have been in this Congress, that you have included a commendation on the veterans handicapped program. I have always felt that it was valuable and important.

I would like to know the types of research that you are talking about. What type of handicapped research are you really referring to?

Dr. MANN. Focusing on the NSF programs?

Mrs. HECKLER. Yes, the NSF programs.

Dr. MANN. Well, I would divide them into two classes. The first class, although I still have reservations, might be reasonably served by Dr. Slaughter's recommendation. The second and more important class already gives evidence of being eliminated by Dr. Slaughter's change. Let me be specific because I am always best with specifics.

Mrs. HECKLER. Yes, it is better to be specific.

Dr. MANN. As an example of the first class, the single most successful high-technology prosthetic device, in my opinion, is the optacon. This reading aid for the blind was invented by John Linville of Stanford University and was subsequently heavily funded by the Bureau for the Physically Handicapped of the Department of Education. Federal support of research and development and then small-scale production for field evaluation led to the creation by John Linville of a small company called Telesensory Systems, Inc. (TSI). TSI has now produced over 8,000 of these optacons which are in use by blind persons worldwide.

Now Dr. Linville has proposed—successfully—to the NSF/STAH program a radical advance in the underlying solid-state electronic technology of the optacon. This same proposal might very well be successful under Dr. Slaughter's recommended change—because John Linville is a superb scientist, and because the proposal addresses discipline and electronic engineering.

However, let me describe proposals of the second class which compete successfully in the future. The radical proposal to devise a training procedure for monkeys to serve as aids for severely impaired individuals, as substitutes for human assistants, being conducted at Tufts would not be approved if STAH is subsumed under the engineering directorate. This research, by no stretch of the imagination, is engineering. But it does have the potential of significant and economic benefit to the spinal-cord injury victim.

The highly successful national competition to utilize personal microcomputers for the handicapped, organized by Johns Hopkins, would not be supportable under the reorganization.

I have two recent proposals to STAH with me, proposed by junior colleagues at MIT. They both have highly rated peer reviews—"excellent" and "very good." Their rejection is based, in my opinion, not on their quality, but rather on the dearth of funding in STAH. In fact, one of them has subsequently been funded by the National Institute of Neurological and Communicative Diseases.

Would this proposal survive Dr. Slaughter's reorganization were my colleague to repropose to NSF? No, it would not because although it has control theory in it—appropriate for electrical engineering—it deals primarily with what causes muscular tremor in humans, a complicated problem which major components in neurophysiology and the pathology of the neuromuscular system, thus heavily medical and heavily physiological. A review of that proposal under the proposed revision of Dr. Slaughter would get poor grades in engineering because the control theory proposed is not a breakthrough.

Let me pick another one. As a final example, I have another proposal with high ratings dealing with improvements in artificial limbs. Here the engineering and robotics are combined with mammalian movement control and neuromuscular physiology. Again, the handicapped targeted proposal becomes so interdisciplinary that I believe it would be poorly treated under Dr. Slaughter's engineering directorate assimulation of the STAH program.

Mr. DYMALLY. Dr. Mann, I am sorry but we have to interrupt you. I think what we will do, because we have had so many interruptions, is submit our questions, in writing. But I think I am going to recommend to the chairman that he invite you back again, if not for formal, certainly for informal questions. I think this is a critical issue. I know Mrs. Heckler shares my view on it.

Dr. Merideth, think about my question about what are you doing in the field of elementary and high school teacher education. We will write to you about that.

Thank you, Dr. Pfafflin.

We will bring on the next panel in about 10 minutes. Thank you.

Mrs. HECKLER. Unfortunately, we will have to pursue the issues again later.

[Recess taken.]

Mr. DYMALLY. We will now bring on the last panel. Will the witnesses identify themselves for the record? We will start with Dr. Fowler, please.

STATEMENTS OF DR. WILLIAM A. FOWLER, INSTITUTE PROFESSOR OF PHYSICS, CALIFORNIA INSTITUTE OF TECHNOLOGY; AND ROBERT SCOTT, DIRECTOR, OFFICE OF FINANCIAL SYSTEMS, HARVARD UNIVERSITY

Dr. FOWLER. I am William A. Fowler, institute professor of physics at Cal-Tech in Pasadena.

Mr. DYMALLY. We note that with interest, Dr. Fowler.

Dr. FOWLER. Do you want me to proceed?

Mr. DYMALLY. Yes, please.

Dr. FOWLER. I am sorry that Mr. Shamansky had to leave because I could tell him that I have a bachelor's degree and an honorary doctor of science from Ohio State University. Maybe you will tell him.

Mr. DYMALLY. That would help, I assure you.

Dr. FOWLER. Mr. Dymally, I welcome this opportunity to testify at these hearings on a matter which has been a concern of mine throughout my professional career, 25 years as an experimental nuclear physicist and the last 15 years as a theoretical astrophysicist, and that matter is instrumentation in university research laboratories.

First I want to emphasize that I am going to present my own personal views but it is true that, as chairman of the Office of Physical Sciences in the National Research Council, which is the operating arm of our two national academies, I am organizing and chairing a workshop on instrumentation needs of university research laboratories to be held next week, March 12 and 13. Participants will come from Government agencies and corporate research laboratories as well as from university research laboratories.

At the National Academy of Science next Friday and Saturday. You will be very welcome.

Mr. **Dymally**. Yes, indeed. We will send an observer, I assure you.

Dr. **Fowler**. Fine. I think Paul Maxwell will be there. I hope so. I hope it will be the beginning of an effective and successful effort to get the instrumentation problem off dead center after a decade of failure. One thing I do know: The NRC is not going to sponsor another study of the instrumentation problem. Every agency representative that I have talked to in Washington assures me the problem is recognized. What is needed are new ideas for a solution, and that ain't going to be easy but the workshop is still to be held, so I have to speak for myself and have to present my own views.

My qualifications for presenting my own views are rather simply stated. In the last 5 years I have visited 37 university or college campuses in the United States to give 86 public lectures, colloquia, and seminars, while in the same period visiting 5 national laboratories or observatories to give 9 talks and 6 foreign universities to give 12 talks. Those visits lasted from 2 to 5 days, which gave me the opportunity to inspect laboratories and to talk with undergraduates, graduate students, post-doctoral fellows, faculty, and sundry department chairmen, deans, provosts, and college presidents.

What did I learn? Certain laboratories on certain campuses were well-instrumented and adequately equipped but the majority were not. In spite of decreased funding in constant dollars, faculty salaries were still increased for merit and inflation. Every effort was made to provide new positions for young faculty members, while graduate students and post-doctoral fellows were not denied opportunities to work in the laboratory or in the observatory. In my heart, I cannot quarrel with that. People come first.

At the same time, costs of operating and maintaining often obsolete equipment markedly increased. The end result, the bottom line, was that funds for new instrumentation were frequently squeezed out of laboratory budgets.

What has been the result? There is a well-documented, growing trend for experimental researchers to leave university laboratories for employment in industrial laboratories. This is usually attributed to the fact that higher salaries are paid in industry than in the universities. That is only partly true. One of the strongest motivations arises from the fact that industrial laboratories are more often than not better equipped, and that industry allocates a higher proportion of its research budget to new instrumentation, relative to salaries and number of personnel.

Let's go beyond university faculty to the graduate students and post-doctoral fellows who do much of the work. In the training of experimental graduate students, we can no longer expect them to spend the increasingly lengthy periods needed to obtain a graduate degree working under the handicap of obsolete instrumentation. The same can be said when they go on to post-doctoral fellowships. Experimental graduate students and post-doctoral fellows must, of course, play a role in constructing the equipment they use. But they must be provided an adequate base in instrumentation already available and adequate support in designing and carrying out modifications or in building entirely new instruments necessary for the solution of their particular problems.

There is a melancholy aspect of the graduate student situation. It is again another well-documented trend, at least in the physical sciences, for graduate students to choose doctoral research in theory rather than in experiment. There are many reasons for this. Work in theory yields an enormous intellectual satisfaction. The deep need to experiment can be satisfied by computer simulation. But that is not all. Why grub away in the laboratory for 4, or 5, or more years to obtain the Ph. D. degree wrestling with vacuum plumbing that leaks, laser beams too weak to do the job, mirrors that need repolishing, accelerators unable to produce high-current, high-resolution beams, travel arrangements to go to SLAC or Fermilab when the wife is working and the kid is too young for nursery school, and your doctoral supervisor can provide no funds even to buy the material to build the instrument you have designed and know must be built or purchased to do your thesis properly? Why not do theory instead? Let there be no misunderstanding here. Of course we need first-rate theorists—but we also need first-rate experimentalists.

What does it matter? Let's turn again to that old question: If things are so bad in American science, why do we continue to dominate the Nobel Prize awards? In my mind the answer is simple. American science has developed a research system that cannot be destroyed overnight and whose fruits will last for some time after the system itself has been destroyed, God forbid.

What do I mean? We have a wonderfully balanced system of research productivity in three places: in university laboratories, in Government laboratories, and in corporate laboratories. Actually I should add a fourth type, the not-for-profit laboratories. The competitive balance is important. Each type of laboratory is unique and essential but one key point must not be forgotten. The Government and corporate laboratories employ and depend upon the graduate product of the university laboratories.

What are we doing in denying adequate instrumentation to our university research laboratories? The eventual long-term result is clear: no more experimental research in our universities and colleges, and I raise the usual specter: we will wind up just like the Soviet Union. Their universities have few graduate research laboratories. A graduate student does his classwork in the university and then goes to do his doctoral research in one of the many research institutes in the Soviet Union. There he can sometimes do very well but only in fields considered important by higher authority. This has led to too much central planning in science in the U.S.S.R. as well as in other matters.

I remember a lovely story that I heard when I played football in high school about a coach who was great on planning ahead. This coach, when his squad played a superior team, said to them: "If we receive, run three plays and punt." The team received all right, ran three plays down to the 1-yard line and punted the ball over the bleachers. The Soviets ought to read our sports page and maybe listen to Bobby Burns.

In my mind the situation is painfully clear. Either we provide adequate instrumentation for university research labs or we lose one essential component in the American way of doing scientific research.

This brings me to what to do about the problem, again my personal views. First of all, I urge this committee to support the NSF thrust in fiscal 1983 to address the problem through the research programs for each scientific discipline. The 1983 budget will provide a total of $95.3 million for scientific equipment, an increase of 11.5 percent over the 1982 plan. This provision of $95.3 million for scientific equipment through the various NSF research programs will help see us through the current period of financial stringency in the U.S. economy.

Eventually, and the sooner the better, there must be an add-on to the budgets of all agencies supporting scientific research in the form of dedicated instrumentation funds. It is my understanding that the DOD fiscal 1983 budget includes $30 million in this form, to meet the instrumentation needs of unclassified programs in basic research in universities and colleges supported by the DOD. That is a modest start in the right direction, but if DOD-supported laboratories need such dedicated funds above and beyond program funds in order to bring their instrumentation up to par, then so do laboratories supported by the NSF and other agencies.

Let me emphasize that dedicated instrumentation needs must represent an add-on to ongoing programs. The need was critical in 1972, 10 years ago, when a minimum of $200 million was documented as the required add-on. During the last decade, as Dr. Langenberg told you this morning, this figure has increased to at least $1 billion and probably to $2 billion because of inflation, continuing obsolescence, and increased complexity and cost of instrumentation. Dedicated instrumentation funds of $200 million per year for 5 years would help considerably. I have to remind you that this figure does not include major new facilities; I am discussing instrumentation up to the $1 or $2 million level.

It is my conviction that these funds must be managed quite independently of current programs. Priorities must be established across disciplines. Competition must be open to obtain awards large enough to bring a given laboratory up to par. Losers the first time around can come back in subsequent years. Perhaps matching funds should be required, but on a graduated scale favoring the smaller colleges. Perhaps younger investigators should be favored. Don't listen to me about details. Given the opportunity, agency management, in cooperation with university faculty and administrators, and with helpful advice from corporate research management, can create a fair and equitable management policy which will restore the vitality and productiveness of our university research laboratories.

However, in the meantime, let's not count our chickens before they are hatched. We are probably not going to get an add on of that magnitude in the 1983 budget, and I have told you that I am very confident in what the Foundation is doing in this regard with the $95 million that it has asked for.

This brings me back to this workshop that I am going to chair. I am hoping that the workshop will be a start toward the development of mechanisms whereby the universities and the agencies, with the counsel of the corporate research laboratory management, can take a good hard look at their management policies. Given the economic facts of life, is too much going into payroll and operating costs and too little into new instrumentation? How much additional help can be expected from the corporate sector in view of new tax incentives? Where are matching funds to come from? Is debt financing a partial answer? We shall see.

Let me conclude: The scientific community in universities realizes that the instrumentation problem will not go away. There are indications that the community is considering Draconian measures, and I use the word advisedly: for example, debt financing, which will involve universities in risk management and in uncertain future commitments. These measures may lead to a solution in the very short term. The critical phase lies down the road. Everyone, including your committee, must look hard and long down that road.

Thank you.

[The prepared statement of Dr. Fowler follows:]

STATEMENT

WILLIAM A. FOWLER

INSTITUTE PROFESSOR OF PHYSICS

CALIFORNIA INSTITUTE OF TECHNOLOGY

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

U. S. HOUSE OF REPRESENTATIVES

MARCH 4, 1982

Mr. Chairman and Members of the committee,

I welcome this opportunity to testify at these hearings on a matter which has been a concern of mine throughout my professional career as an experimental nuclear physicist for the first 25 years and a theoretical astrophysicist for the last 15 years. That matter is instrumentation in university research laboratories. Almost exactly three years ago the late Philip Handler, then President of the National Academy of Sciences, testified before this Subcommittee on March 6, 1979. He began:

> "First, the matter of instrumentation. As you know, from 1967 to 1976 basic research was insufficiently funded to adequately support the enterprise already in being. During that time we used up much of our capital. Available funds were stretched as far as possible, used largely to pay salaries and consumable supplies while instrumentation requirements languished."

He concluded his remarks on instrumentation with:

> "Science is paced by ideas and instrumentation; it is wasteful and unwise to fail to provide adequate instrumentation if it is our society's intention that our scientific cadre shall be as productive as possible."

I can say it no better, but perhaps you will permit me to present my views on a problem which is now even more critical than when Philip Handler spoke three years ago. You are not going to hear from me a litany of what science can do for the general welfare, for the economy, and for the National defense. That has been well stated by many more persuasive than myself. I speak of the critical instrumentation situation in university research laboratories. First, I emphasize that I am presenting my personal views. It is true that as Chairman of the Office of Physical Sciences in the National Research Council I am organizing a Work Shop on Instrumentation Needs of University Research Laboratories to be held March 12 and 13. Participants will come from government agencies and corporate research laboratories as well as from university research laboratories. I hope it will be the beginning of an effective and successful effort to get the instrumentation problem off dead center after a decade of failure. One thing I do know. The NRC is not going to sponsor another study of the instrumentation problem. Every agency representative I have talked to in Washington assures me the problem is recognized. What is needed are new ideas for a solution and that isn't going to be easy. But the workshop is still to be held and so I speak for myself.

Three studies of the instrumentation problem serve as background for my testimony. They are:

(1) The NSF/NAS Survey of Research Equipment Needs in Ten Academic Disciplines (February 1972). As a member of the National Science Board at that time I enthusiastically supported the request for this study by the NAS to the NSF and I was convinced that the bottom line of the Survey was realistic. That bottom line was:

> "The magnitude of the need is easily abstracted. It is large -- i.e., well over $200 million in spite of the exclusion from the survey of equipment requiring additional staff."

The Survey was never published as an official NSF document. Nevertheless, NSF staff members have remained aware of the problem and have done much in their power to attempt to alleviate the problem over the past decade. I endorse NSF policies to date and their hopes for the future. In a recent talk to the Cosmos Club, John Slaughter, Director of the NSF said: "We must also address the increasing deterioration and obsolescence of research equipment and instrumentation at universities. Meeting the most pressing of these needs puts additional pressure on our available funds for research."

(2) The Scientific Instrumentation Needs of Research Universities, a report to the NSF by the Association of American Universities, June 1980.

(3) The Nation's Deteriorating University Research Facilities, a report prepared for the Committee on Science and Research of the AAU, July 1981.

These AAU reports convince me that the instrumentation problem is still with us and that unless it is cured, scientific research in the United States is in for trouble. In my book these two AAU reports are excellent in data base, analysis and presentation.

In addition, an Interagency Instrumentation Study chaired by Dr. Donald Langenberg, Deputy Director of the NSF, worked the problem. You have just heard from Dr Langenberg about the plan for a special multi-year government-wide initiative which was developed by the Interagency Study.

The two AAU reports should be available to this Subcommittee, so let me emphasize once again that I have chosen to present my own views. My qualifications for doing this are simply stated. In the last five years I have visited 37 university or college campuses in the United States to give 86 public lectures, colloquia and seminars, while in the same period visiting 5 national laboratories or observatories to give 9 talks, and 6 foreign universities to give 12 talks. Those visits lasted from two to five days which gave me the opportunity to inspect laboratories and to talk with undergraduates, graduate students, post-doctoral fellows, faculty and sundry department chairmen, deans, provosts and college presidents.

What did I learn? Certain laboratories on certain campuses were well instrumented and adequately equipped but the majority were not. Philip Handler was right. In spite of decreased funding in constant dollars, faculty salaries were still increased for merit and for inflation, and every effort was made to provide new positions for young faculty members, while graduate students and post-doctoral fellows were not denied opportunities to work in the laboratory or in the observatory. In my heart I cannot quarrel with that -- people come first. At the same time, costs of operating and maintaining often obsolete equipment markedly increased. The end result was that funds for new instrumentation were frequently squeezed out of laboratory budgets.

What has been the result? There is the well-documented growing trend for experimental researchers to leave university laboratories for employment in industrial laboratories. This is usually attributed to the fact that higher salaries are paid in industry than in the universities. This is only partly true. One of the strongest motivations arises from the fact that industrial laboratories are more often than not better equipped and that industry allocates a high proportion of its research budget to new instrumentation relative to salaries and number of personnel.

Let's go beyond university faculty to the graduate students and post-doctoral fellows who do much of the work. In the training of experimental graduate students, we can no longer expect them to spend the increasingly lengthy periods needed to obtain a graduate degree working under the handicap of obsolete instrumentation. The same can be said when they go on to post-doctoral fellowships. Experimental graduate students and post-doctoral fellows must, of course, play a role in constructing the equipment they use. But they must be provided an adequate base in instrumentation already available and adequate support in designing and carrying out modifications or in building entirely new instruments necessary for the solution of their particular problems.

There is a melancholy aspect of the graduate student situation. It is again another well-documented trend, at least in the physical sciences, for graduate students to choose doctoral research in theory rather than in experiment. There are many reasons for this. Work in theory yields an enormous intellectual satisfaction. The deep need to experiment can be satisfied by computer simulation. But that is not all. Why grub away in the laboratory for four or five or more years to obtain the Ph.D. degree wrestling with vacuum plumbing that leaks, laser beams too weak to do the job, mirrors that need repolishing, accelerators unable to produce high-current, high-resolution beams, travel arrangements to go to SLAC or Fermilab when the wife is working and the kid is too young for nursery school, and your doctoral supervisor can provide no funds even to buy the materal to build the instrument you have designed and know must be built or purchased to do your thesis properly? Why not do theory instead? Let there be no misunderstanding here. Of course we need first-rate theorists -- but we also need first-rate experimentalists.

What does it matter? Let's turn again to the old question -- if things are so bad in American science, why do we continue to dominate Nobel Prize Awards? In my mind the answer is simple; American science has developed a research system that cannot be destroyed overnight and whose fruits will last for some time after the system itself has been destroyed, God forbid. What do I mean? We have a wonderfully balanced system of research productivity in university laboratories, in national laboratories, and in corporate laboratories. The competitive balance is important -- each type of laboratory is unique and essential -- but one key point must not be forgotten. The national and corporate laboratories employ and depend upon the graduate product of the university laboratories.

What are we doing in denying adequate instrumentation to our university research laboratories? The eventual long-term result is clear -- no more experimental research in our universities and colleges. I raise the usual specter. We will wind up just like the Soviet Union. Their universities have few graduate research laboratories. A graduate student does his class work in the university and then goes to do his doctoral research in one of the many research institutes in the Soviet Union. There he can sometimes do very well indeed, but only in fields considered important by higher authority.

This has led the Soviets to too much central planning in science as in other matters. When I played high school football I got a big kick out of the story about the coach who was great for planning ahead. Before a game against a superior squad he told his team: "If you receive, run three plays and punt." Well, the team received all right, ran three plays down to the one-yard line and punted the ball over the bleachers. The Soviets ought to read our sports pages or maybe even Robert Burns. He was right!

Let's get back to the United States. In my mind the situation is painfully clear. Either we provide adequate instrumentation for university research laboratories or we lose one essential component in the American way of doing scientific research.

What is needed? It is not possible here to give an exhaustive list of instruments used in astronomy, physics, and chemistry. A partial list would include such instruments as:

-- advanced astronomical detectors and spectrometers
-- nuclear magnetic resonance spectrometers
-- chromatrographs, gas andliquid
-- mass spectrometers of various types
-- small accelerators of various types
-- cryogenic equipment for work in superconductivity
-- electron microscopes
-- electron microprobes
-- lasers
-- mini and micro computers
-- mossbauer spectrometers
-- ultrahigh vacuum systems

This brings me to what to do about the problem -- again I emphasize these are my personal views. First of all, I urge this Subcommittee to support the NSF thrust in FY 1983 to address the problem through the research programs for each scientific discipline. The FY 1983 budget will provide a total of 95.3 million dollars for scientific equipment, an increase of 11.5 per cent over the FY 1982 current plan. This allocation of 95.3 million dollars is 8.9 per cent of the total NSF budget of 1073 million dollars and 9.7 per cent of that allocated for the conduct of basic research.

The provision of 95.3 million dollars for scientific equipment in FY 1983 through the various NSF research programs will help see us through the current period of financial stringency in the U.S. economy. Eventually, and the sooner the better, there must be an add-on to the budgets of all agencies supporting scientific research in the form of dedicated instrumentation funds.

It is my understanding that the DoD FY 1983 budget includes 30 million dollars in this form to meet the instrumentation needs of unclassified programs in basic research in universities and colleges supported by the DoD. That is a modest start in the right direction. But if DoD-supported laboratories need such dedicated funds above and beyond program funds in order to bring their instrumentation up to par, then so do laboratories supported by the NSF and other agencies.

Let me emphasize that dedicated instrumentation funds must represent an add-on to ongoing program needs. The need was critical in 1972 when a minimum of 200 million dollars was documented as the required add-on. During the last decade, this figure has increased to at least 1 billion dollars because of inflation, continuing obsolescence and increased complexity and cost of instrumentation. Dedicated instrumentation funds of 200 million dollars per year for five years would help considerably.

It is my conviction that these funds must be managed quite independently of current programs. Priorities must be established across disciplines. Competition must be open to obtain awards large enough to bring a given laboratory up to par. Losers the first time around can come back in subsequent years. Perhaps matching funds should be required, but on a graduated scale favoring the smaller colleges. Perhaps younger investigators should be favored. Don't listen to me about details. Given the opportunity, agency management in cooperation with university faculty and administrators, and with helpful advice from corporate research management, can create a fair and equitable management policy which will restore the vitality and productiveness of our university research laboratories.

In the meantime, there is no point to counting one's chickens before they hatch. That brings me back to the Workshop on Instrumentation Needs of University Research Laboratories which I will chair next week. I am hoping that the workshop will be a start toward the development of mechanisms whereby the universities and the agencies with the counsel of the corporate sector can take a good hard look at their management policies in the limited areas of astronomy, physics, and chemistry. Given the economic facts of life, is too much going into payroll and operating costs and too little into new instrumentation? How much additional help can be expected from the corporate sector in view of new tax incentives? Where are matching funds to come from? Is debt financing a partial answer? We shall see.

What is the growing tendency for research faculty and their students to form users' groups and spend extended periods at regional or national laboratories doing to university life? How many disciplines besides high energy physics, space science, and big telescope astronomy must go this way? How are you going to keep them down on the farm after they have been out to SLAC? Let's study the problem and not let it be solved by default.

Let me conclude. The scientific community in universities realizes that the instrumentation problem will not go away. There are indications that the community is considering draconian measures -- for example, debt financing, which will involve universities in risk management and uncertain future commitments. These measures may lead to a solution in the very short term. The critical phase lies down the road. Everyone, including this committee, must look hard and long down that road.

Thank you.

Mr. **Dymally**. Thank you, Dr. Fowler.

Mr. Scott?

[The biographical sketch of Mr. Scott follows:]

CURRICULUM VITAE

ROBERT HUGH SCOTT
Director of the Office of Financial Systems and
Associate Dean for Resource Planning of the
Faculty of Arts and Sciences
Harvard University
1350 Massachusetts Avenue
Cambridge, Massachusetts 02138
(617) 495-2522

Home Address: 12 Myles Standish Road
Weston, Massachusetts 02193

Birth Date: April 5, 1943

I. EDUCATION

A. Graduate Study in Management, Information and Computer Systems, and Mathematics, 1964-67 (part-time), MIT.

B. S.B. in Economics, Politics, and Science, 1964, MIT.
Course Specializations: Political Science and Physics.
Thesis Title: Political Aspects of Planning in the Metropolitan Boston Area. Areas of interest: Science Policy, International Affairs and Arms Control, Physics.

II. PROFESSIONAL EXPERIENCE

A. Employment History

Director of the Office of Financial Systems, Harvard University, November 1977 to present (Acting Director - February 1977 to November 1977).

Associate Dean for Resource Planning of the Faculty of Arts and Sciences, Harvard University, September 1980 to present.

Director of the Office for Information Technology, Harvard University, May 1976 to August 1980.

Director of Information Processing Services, MIT, January 1970 to May 1976.

Assistant Dean of Engineering and Associate in the Analytical Studies Group, MIT, July 1969 to December 1969.

Assistant Dean of Engineering, MIT, July 1968 to June 1969.

Assistant to the Dean of Engineering, MIT, June 1964 to June 1968.

1. Director of the Office of Financial Systems, Harvard University

   Responsible for the direction and management of essentially all of the central financial operating functions of the University. Activities supervised include the comptrollership and financial planning functions together with operating activities such as Accounting, Accounts Receivable, Accounts Payable, Payroll, Purchasing, Research Administration, Student Loans and Internal Audit for a decentralized University with an annual budget of approximately $440,000,000. Responsible for defining, developing and implementing programs to improve the control of non-investment assets, for developing and operating information systems to provide planning and control information to department managers, and for assuring that the University's financial affairs are conducted and controlled effectively and efficiently and with sensitivity to the purpose, mission and character of the University. Work closely with the University's Corporation, President, Deans and Vice Presidents in identifying and capitalizing on financial opportunities and on resolving financial problems. An annual budget of $7,900,000 and 175 employees are supervised.

2. Associate Dean for Resource Planning of the Faculty of Arts and Sciences, Harvard University

   Responsible for developing a coordinated approach to planning the financial and physical development and the longer-term financial stability of Harvard's Faculty of Arts and Sciences, which is the University's largest department and which encompasses an annual budget of $135,000,000, 9,000 students, and a faculty of 500. Specific responsibilities include proposing growth rates for the major controllable sources of income and expense, including tuition, faculty salaries, student aid, and capital facilities, and establishing policies and procedures for assuring that short-term decisions reflect established longer-term objectives. Responsible for developing an organized approach to longer-term planning which facilitates short-term planning and provides a structure for decision making.

3. Director of the Office for Information Technology, Harvard University

   Responsible for the planning, development and management of the University's information systems activities including central computer service facilities, administrative systems development programs, cable and broadcast television and video-service systems, telecommunications facilities and equipment, word processing and office automation programs, and both central and distributed copy services. Responsible for University-wide coordination of information technology activities; for encouraging the effective and efficient use of technology in the University's teaching, research, library and administrative programs; and for encouraging the development of national programs of information and resource sharing relating to the application of developing information technologies to the University community. Annual budget (1980 dollars) for all activities was $10,600,000 and 170 employees are supervised.

4. Director of Information Processing Services, MIT

Responsible for the development and implementation of plans and programs to provide information processing services to meet the needs of the instructional, research, and administrative components of the MIT commmunity; representation of MIT to external organizations; participation in the development of nationally based programs to share computing resources; operation of all MIT computer service facilities; promotion of effective and efficient use of information and of information processingtechniques in all phases of MIT's operation; determination of budgets for computer service; and initiation and development of new programs. Specific activities involved direct administration of central service facilities and coordination between central and departmental installations containing eleven major computing systems and approximately two hundred more specialized computer facilities for research or teaching. These facilities served all MIT Departments and Laboratories, together with many neighboring universities. Total annual budget (1976 dollars) exceeded $11,000,000 and 150 employees were supervised.

5. Analytical Studies Group, MIT

Study and analysis of mechanisms for decision making in a university. Particular studies focused on policy determination, tuition establishment, space assignment, and information use.

6. Office of Dean of Engineering, MIT

Shared with the Dean responsibility for the administration of MIT's largest school with an annual budget (1969 dollars) of approximately $40,000,000. Activities included academic and program planning, personnel appointment, budget negotiation and establishment, research program initiation, space assignment, and general administration. Major specific projects included the first phase of planning for the development of a program in Engineering and Living Systems and initial planning and implementation of a total reorganization and development of MIT's central computer facilities.

Mr. Scott. Thank you, Mr. Chairman.

My name is Robert Scott. I am the director of the office of financial systems at Harvard University. In this position I am responsible for the majority of our financial operations, including the administrative aspects of research and the planning and financing of equipment and other capital facilities.

As has been said so eloquently by many others before me today who are directly involved with the performance of science, scientific research is critically important to the success of American technological and economic development and to insuring a strong, competitive position for American industry. High-quality scientific research depends in large measure on the production of intellectual capital and trained men and women within the Nation's universities. These processes cannot take place without adequate modern facilities, and they are now constrained by an aging physical plant.

I welcome your invitation to testify before the committee today on this important matter. I would like to use this opportunity to review with you our own particular analysis of the problem, to describe some of the approaches to solving this problem which we have been considering, and also to suggest some actions which I believe the Congress and the executive branch might take which would assist universities in this important area.

Stated in its very simplest terms, universities attempting today to provide adequate scientific facilities face a problem of capitalization, more specifically, a problem of a lack of capitalization. Traditional methods of university management and financing have not provided significant levels of internal investment capital or risk capital to finance the construction of facilities, to furnish those facilities with the necessary equipment or to provide adequate seed funds to support ventures into potentially productive fields of research. This situation, which pervades higher education, is particularly pronounced with regard to fields of science, since those fields have become extremely capital-intensive and since the costs of the necessary construction have been particularly high.

The issue is compounded by the fact that universities must work to address the capitalization problem during a period of great financial change for higher education. Since the mid-1960's, universities have faced continuously more complex and intractable financial problems and have needed to make significant and difficult financial decisions that balance competing demands for limited resources. The decade of the 1980's does not promise to be one of expansion for higher education in general, yet, it is during this decade that we must work to find an acceptable way to address the problems posed by the need to replace this plant.

Universities do not face the same financial incentives for investment in plant as profitmaking organizations. In part because universities are not taxpaying entities, we have tended to develop capital and pricing structures that do not accurately and fully reflect the cost of facilities and equipment. Capital costs have typically been met by private contributors, by State legislators, or by the Federal Government. In general, annual university operating budgets, including research budgets, have met only a very small fraction of the true costs of the facilities consumed during the periods covered by those budgets.

Particularly in the case of research facilities, where change has been particularly rapid during the past three decades, a large fraction of the capital support has been provided either directly or indirectly by the Federal Government. Much of the excellence of American science is the result of this forward-thinking investment.

Today universities must plan for the development of this physical plant under two opposing constraints. On the one hand, the need for investment in scientific facilities is greater than it ever has been in the past the rate of change within the fields of science which we all seek to support is increasing, and that rapid change requires that laboratory renovation and reequipping occur with considerable and increasing frequency. The simple fact is that laboratories need to be renovated frequently if modern science is to be conducted at all, and in particular, conducted effectively, efficiently, and safely. On the other hand, we face these needs during a time when Federal support for equipment and other capital programs has decreased.

The traditional solution adopted by private universities to the need to provide capital facilities for research has been to seek support for the required facilities either directly from sponsors of the related research in the Federal Government or in industry or from general donors. When successful, this approach covers in advance the entire capital cost and resolves, in a sense, the capital problem.

However, this approach is particularly expensive to those providing support, for it neither distributes the cost of the facilities across the several years during which they will be used nor assigns a fair share of the cost to the many programs which will benefit from one particular set of facilities. This practice has contributed to the decline in the level of equipment available, since research sponsors have resisted the practice, and since institutions, facing the need to decide between staff support and equipment, do not want to make large capital expenditures.

To the extent that Federal support of capital costs is still available, the majority of that support is provided as a part of annual budgets. The expenses covered by those budgets are used largely to pay annual costs, such as salaries, travel, supplies, and so forth. A decision to acquire a piece of capital equipment, therefore, is particularly hard since it requires the use of annual funds to incur up front a cost which will benefit not only the current budget period but also other periods to come in the future.

When annual funds are used for capital purposes, and when the equipment provided will be used over a period of years, then a capital expenditure made by one grant will assist related grants which are conducted in subsequent years just as the grant making the capital expenditure will, in all probability, benefit from similar capital investments made by other grants in the past. For example, if a grant budget is to provide on a current basis the entire capital cost of a piece of equipment that will last for 7 years and that will be used equally by three research programs, then the charge to that grant will be over 20 times larger than it would be if the grant covered only the cost related to its share of that equipment during the first year of its useful life.

An alternative way for universities to manage their capital affairs is to follow the industrial analog and to consider these costs as investments which should be depreciated or amortized over a period of time. This approach has much to recommend it. First, costs would be assigned to the specific programs which they benefit and individual programs do not subsidize each other. Second, using this approach, universities would be able to plan far more effectively for their equipment needs, since they would be able to acquire equipment on a well-thought-out schedule and without particular regard to the level of support which happens to be available in the very short term.

Of course, this approach also brings with it some risks. If a university is to acquire equipment on a capitalized basis, it must make a commitment to bear the cost in future years. A university may not know precisely and in advance what research equipment it will need for future research projects, nor will it know what level of support will be available in annual budgets to support the costs of equipment purchased for the future. This, of course, is precisely the same risk which universities now accept when they construct and renovate buildings. A balanced approach is surely possible, under which universities ask their annual budgets to cover less of the cost of equipment purchased and to cover instead a reasonable share of the cost of that equipment, a share that reflects the likely lifetime of equipment and also its utility to various programs.

I believe personally that much can be done to address this problem if universities are able to plan and acquire capital research facilities which they need through internal financing, through conventional and tax-exempt debt, and through leases. At Harvard, we have considered and, in a number of cases, tried a number of these alternatives and we are developing specific plans in a number of areas. A number of other universities have also moved in this direction.

There are, however, a number of obstacles which institutions face as they try to address these problems and to use new kinds of approaches. I would like to suggest for your consideration several categories of consideration which would be helpful.

First, any capitalization brings with it a real or imputed interest cost. Interest rates, as you well know, are now at an extremely high level yet Federal regulations specifically prohibit the recovery from federally sponsored research projects of those projects' fair share of interest costs associated with the facilities. The Office of Management and Budget has recently proposed a change in this area which would solve the problem for the future, and I strongly urge anyone who can to encourage OMB to make that change official.

Mr. **DYMALLY**. Would that be an administrative rule or some statutory change?

Mr. **SCOTT**. That is an administrative rule, Mr. Chairman, and the Office of Management and Budget has proposed a change. I just want to note for your record that it is very important, in my view, that they make the change formally.

The removal of this barrier will eliminate a number of economic disincentives. For example, rental space is all too frequently used instead of purchased space, even though it is more expensive, for the simple reason that rental costs are covered and the interest on capital facilities is not.

The second major point has to do with tax financing. Universities are tax-exempt organizations. As a result, the equipment which they purchase does not carry investment tax credits, regardless of whether it is owned by the university itself or owned by a third party and leased to the university. This is a particularly unfortunate situation, since it reduces the incentives for universities to purchase equipment and to use novel financing methods. In fact, since it is in the universities that much of the intellectual capital of the Nation's science is generated, the National Government should, I think, provide the greatest incentives for capital investment in these institutions.

The investment tax credit should be made available for equipment used by universities. Such a change would reduce the cost of research equipment acquired by universities by permitting universities to benefit from the tax incentives which the Nation has determined should apply to the purchase of assets designed to improve our productivity.

The third area of potential action has to do with providing incentives to private individuals and corporations to make capital equipment and facilities available to universities. For example, decreasing the limits which now exist on charitable deductions or allowing donors to utilize investment tax credits or depreciation credits on equipment which they plan to donate could make significant improvements to the equipment environment which universities now face. Also, if limits which now exist on research and development tax credits for research performed at universities under corporate sponsorship were removed, then industry would have increased incentives to support university programs.

In general, I believe that economic efficiency will be greatly improved if business and industry are permitted or—perhaps even more important—encouraged by the Tax Code to support the training of scientists and engineers and to provide for the development of the intellectual capital which universities provide.

I welcome this opportunity to discuss these issues with you, and I would be glad to answer any questions you have.

[The prepared statement of Robert Scott follows:]

TESTIMONY BEFORE THE SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
OF THE COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

MARCH 4, 1982

Mr. Chairman:

My name is Robert Scott and I am Director of the Office of Financial Systems at Harvard University. In this position, I am responsible for the majority of our financial operations, including both research administration and capital financing.

Scientific research is critically important to national technological and economic development and to assuring a strong, competitive position for American industry. The success of that scientific research depends in large measure on the production of intellectual capital and highly trained men and women within the nation's universities. These processes, which cannot take place without adequate, modern facilities, are now constrained by an aging physical plant. I welcome your invitation to testify before the Subcommittee today on this important matter. I would like to use this opportunity to review with you our analysis, to describe some of the approaches to solving this problem which we have taken or are considering, and to suggest actions which Congress and the Executive Branch might take to assist universities in this very important area.

Stated in its simplest terms, universities attempting today to provide adequate scientific facilities face a problem of capitalization--specifically, a problem of lack of capitalization. Traditional methods of university management and financing have not provided significant levels of internal investment capital or risk capital to finance the construction of facilities, to furnish those facilities with the necessary equipment, or to provide adequate seed funds to support ventures into potentially productive fields of research. This situation is particularly pronounced with regard to scientific research since these fields have become quite capital intensive, since the cost for the necessary construction is particularly high, and since the early availability of the latest equipment is particularly important.

This situation is compounded by the fact that universities must work to address the capitalization problem during a period of great financial change for higher education. Since the mid-1960's, universities have faced continuously more complex and intractable financial problems and have needed to make increasingly difficult financial decisions that balance competing demands for limited resources. The decade of the 1980's does not promise to be one of expansion for higher education in general and yet it is during this decade that we must find an acceptable way to address the problems posed by the need to replace obsolete laboratory equipment.

Universities do not face the same financial incentives for investment in plant as do profit-making organizations. In part because universities are not tax-paying entities, they have tended to develop capital and pricing structures which do not accurately and fully reflect the costs of facilities and equipment. Capital costs have typically been met by private contributors, state legislatures, or the federal government. In general, annual university operating budgets have met only a very small fraction of the true costs of the facilities consumed during the period covered by those budgets. Particularly in the case of research facilities, where change has been particularly rapid during the past three decades, a large fraction of the capital support has been provided--directly or indirectly--by the federal government. Much of the excellence of American science is the result of this forward-thinking investment.

Universities today must plan for the development of their physical plant under two opposing constraints. On the one hand, the need for investment in scientific facilities is greater than it has ever been in the past. The rate of change within the fields of science which we all seek to support is increasing and that rapid change requires that laboratory renovation and re-equipping occur with considerable and increasing frequency. The simple fact is that laboratories need to be renovated frequently if modern science is to be conducted effectively, efficiently, and safely.

On the other hand, we face these needs during a time when federal support for equipment and other capital programs has decreased. Much of the equipment provided during the period of great expansion in federal support of university research between the mid-forties and the mid-sixties has been fully depreciated and is rapidly becoming obsolete. Increasingly, universities are making do with facilities that are not adequate or which limit the effectiveness and efficiency with which scientific research is conducted. It is frequently impossible to undertake new fields of scientific inquiry without new equipment. More often each year, universities must compromise or forgo opportunities to move into areas in which they could make significant and unique contributions to the advancement of knowledge.

The growing need universities face for investment in research facilities and the decreasing level of real support for research provided by the federal government, which has been the traditional sponsor of these programs, are combining to cause a significant problem. I know that this description will hardly be a surprise to you. However, I believe it worth restating in these terms because a number of the potential solutions to the problem we jointly face may be suggested by comparisons between the methods of management within universities and the relatively more successful efforts of industry to provide capital funds for their programs.

The traditional solution adopted by private universities to the need to provide capital facilities for research has been to seek support for the required facilities either from the sponsors of the related research in the federal government or industry or from general donors. When successful, this approach has covered in advance the entire capital cost anticipated. When successful, this is an excellent approach for it will resolve the problem. However, this approach is a particularly expensive to those providing support for it neither distributes the costs of the facilities provided across the several years during which they will be used nor assigns a fair share of the cost to the many programs which will benefit from those facilities. This practice has contributed to the decline in the level of equipment available since research sponsors have resisted such practices as funds have become scarcer.

To the extent that federal support of capital costs is still available, the majority of that support is provided as a part of the budgets of annual grants. Since the expenses covered by such budgets are used largely to pay annual costs such as salaries, travel, supplies, and indirect costs, a decision to acquire capital equipment is particularly hard since it requires the use of annual funds to incur up front a cost which will benefit not only the current budget period, but also other periods to come in the future. When annual funds are used for capital purposes and when the equipment provided will be used over a period of years, then a capital expenditure made by one grant will assist related grants which are conducted in subsequent years, just as the grant making the capital expenditure will in all probability benefit from capital expenditures made by related grants in previous years. For example, if a grant budget is to provide the capital cost for a piece of equipment that will last for seven years, then the charge to that grant will be seven times larger than it would be if the grant covered by the cost related to the first year of the useful life of that piece of equipment.

This financing method has been the method of choice for many years. There are several reasons for this state of affairs, not the least of which are that it has been possible and conservative. However, consider for a moment where private industry or individual families would be today if each needed to provide capital costs without charging those costs to future annual budgets. Far less capital investment would be possible.

An alternative way for universities to manage their capital affairs is to follow the industrial analog and to consider these costs as investments which should be financed and then written off over a period of time. This approach has much to recommend it. First, costs are assigned to the specific programs which they benefit and individual programs do not subsidize each other. Second, using this approach, universities will be able to plan far more effectively for their equipment needs since they will be able to acquire equipment on a well-thought-out schedule and without particular regard to the level of support which happens to be available in the very short term.

On the other hand, such an approach is not without risk for, if a university is to acquire equipment on a capitalized basis, it must make a commitment to bear the cost in future years. A university may not know precisely and in advance what research equipment it will need for future research projects nor will it know what level of support will be available in annual budgets to support the costs of equipment purchased for the future. This, of course, is precisely the risk which universities now take when they construct or renovate buildings. A balanced approach is surely possible under which universities ask their annual budgets to cover less of the cost of equipment purchases and to cover, instead, a reasonable share of the cost of that equipment: a share that reflects the likely lifetime of that equipment and its utility to other programs.

In short, I believe that much can be done to address this problem if universities are able to plan and acquire the capital research facilities which they need through internal financing, through conventional or tax-exempt debt, or through leases. At Harvard, we have considered a number of these alternatives and have developed specific plans in several areas. Other universities have also moved in this direction. There are, however, a number of obstacles which we face. I would like to suggest for your consideration changes to laws and regulations which would make these new approaches more easily achievable.

1. Any capitalization brings with it a real or imputed interest cost. Interest rates are now at relatively high levels yet federal regulations specifically prohibit the recovery from federally sponsored research projects of those projects' shares of interest costs associated with the capital facilities they use. The Office of Management and Budget has proposed a change to the regulations in this area which are contained in OMB Circular A-21. This change would permit inclusion of relevant interest costs in the costs of research beginning on July 1, 1982. Formal adoption of this change is critically important for it will remove the most significant barrier which has faced those trying to develop imaginative and constructive capital financing systems. In addition, removal of the barrier which now exists will eliminate a number of economic disincentives. For example, rental space is frequently used instead of purchased space, even though more expensive, for the simple reason that its costs are fully recognized in the relevant federal regulations while the costs of purchased space are only partially recognized.

2. Universities are tax-exempt organizations. As a result, the equipment which they purchase carries no investment tax credit regardless of whether it is owned

by the university itself or owned by a third party and leased to the university. This is a particularly unfortunate situation since it reduces the incentives for universities to purchase equipment. In fact, since it is in universities that much of the intellectual capital of the nation's science is generated, the national government should provide the greatest incentives for capital investment in these institutions. The investment tax credit should be made available for equipment used in universities. Such a change will reduce the cost of research equipment acquired by universities by permitting universities to benefit from the tax incentives which the nation has determined should apply to the purchase of assets designed to improve productivity.

3. All possible action should be taken to improve the incentives for private individuals and corporations to make capital equipment and facilities available to universities. For example, decreasing the limits which now exist on charitable deductions or allowing donors to utilize investment tax or depreciation credits on equipment which they donate could each make significant improvements to the equipment environment in universities. Also, if limits which exist on research and development tax credits for research performed at universities under corporate sponsorship were removed, then industry would be encouraged to support university programs more fully. In general, I believe that economic efficiency will be very greatly improved if business and industry are permitted--or, more important, encouraged--by the tax code to support the training of scientists and engineers and to provide for the development of intellectual capital through the support of universities. This, I believe, would be far more efficient and productive than would be the collection of those same funds through the tax system and their subsequent distribution through the budgets of relevant granting agencies.

I welcome this opportunity to discuss this important problem area with the Subcommittee. At Harvard, we realize that our scientific research activities must be based on modern, well-designed, and well-equipped laboratories. We recognize that the construction and equipping of those laboratories is our responsibility and we are developing the financial programs which are required to assure success. We appreciate the direct assistance which the federal government has provided in the past and can provide in the future. However, it is equally important that everything possible be done to encourage others to invest in university research and to permit universities to address this issue without undue disadvantage but rather with every positive incentive.

I will, of course, be glad to answer any questions you may have. Thank you.

Mr. DYMALLY. Before I call on Mrs. Heckler, just one request of you: Could you forward to the committee a list of specific changes you would like to see in the tax law?

Mr. SCOTT. I certainly will do that.

Mr. DYMALLY. Mr. Scott, you should have been here last year during the bidding war. You might have gotten everything. I mean, everybody was upping the ante. The Democrats came in and the Republicans came in, and the oil folks and the cattle folks. Everybody but the universities got a little piece of the action.

Mr. SCOTT. Mr. Chairman, I believe that is a very telling remark. I believe universities have tended not to think sufficiently about this issue simply because they have operated exclusively in the tax-exempt environment and they have not addressed the way in which tax incentives affect them indirectly. These incentives are so important to many parts of our society, they can make a great difference to universities as well.

Mr. DYMALLY. Dr. Fowler, in your travels overseas, what was your observation vis-a-vis instrumentation over there and in our universities here?

Dr. FOWLER. Well, sir, it varies. The United Kingdom is having worse problems than we are having, and the instrumentation in their laboratories is really very, very poor.

West Germany, on the other hand, has—I think it is generally agreed—far better equipment, in those laboratories that they are strongly supporting, than we have in our labs. The West Germans tend toward a system in which many of the large laboratories are either in the Max Planck Institutes or in their other federal institutes.

France is about the same as the United States with the notable exception that the French have many, many more technicians per scientist than we have in our laboratories. It has been a tradition in France that the scientist does not get his hands dirty. He has a technician to do the work for him. Overall, I would say that we are definitely behind West Germany and France.

Mr. **Dymally**. What about Japan or Russia?

Dr. **Fowler**. Japan is spotty. They have selected certain fields of physics, chemistry, and astronomy in which to excel. They are wise in not trying to do too much. If you go into a Japanese laboratory that has the encouragement of the Japanese Government, then they are very well equipped. They do not always have people who know how to use some of the very sophisticated equipment that they have but the Japanese do very well when they make up their minds to do something.

Mr. **Dymally**. When the Government makes up its mind that you are going in this direction, then everybody follows.

Dr. **Fowler**. That is even more true in the Soviet Union, Mr. Dymally, as you well know. You can go into laboratories in the Soviet Union—I have been all over the Soviet Union many times—and any laboratory that the Government wants to support to the hilt is equipped superbly in terms of their technological standards. You must get the feeling from what I have already said that I do not think that they are up with us but when they want to do something like land on Venus——

Mr. **Dymally**. They go.

Dr. **Fowler** [continuing]. They do it. However, I think our system where we still have freedom of choice—a youngster can decide what his doctoral thesis is to be—is far superior. We have to keep that component because that component operates in good measure in our university research laboratories.

Mr. **Dymally**. Dr. Fowler and Mr. Scott, we will have to leave unceremoniously again. No, wait a minute. Mrs. Heckler has about 2½ minutes with you. We will conclude after Mrs. Heckler finishes. We want to thank you very much. I want to compliment the quality of testimony we had today.

Mrs. Heckler?

Mrs. **Heckler**. Thank you. You know it is a compliment to Massachusetts.

Mr. **Dymally**. Indeed it is.

Mrs. **Heckler**. You realize how many Massachusetts witnesses we have today?

Dr. **Fowler**. California?

Mrs. **Heckler**. California? I was going to claim you, Dr. Fowler. It is too bad. You sounded like Massachusetts. It was that good.

Dr. **Fowler**. Well, you know, there is a connection. At Caltech where I am located, we consider MIT our east coast branch.

Mrs. **Heckler**. Or vice versa? [Laughter.]

Dr. **Fowler**. It is a much larger branch.

Mrs. **Heckler**. I think the testimony has been excellent. I would like to tell my colleague that we did do something for the universities and it was a bidding war over the Economic Recovery Act, especially the tax package, unfortunately. That is partially why we have such enormous deficits, all the giveaways, but one of the areas of the Tax Code change that I suggested was the R. & D. credits for donations to universities. That was not prompted by university lobbying but by industry lobbying. Nevertheless it was important. It was an important beginning.

Mr. **Dymally**. Mrs. Heckler, you have a bill that you are proposing now?

Mrs. **Heckler**. Yes; I have a bill now which would not help the universities but I think it is very important in technology, and that is to have a tax credit for the donation of equipment to local schools, to start that process at a much earlier age.

There are many questions that are in the forefront of my mind in relation to both of your excellent testimonies, but in view of the timeframe in which we find ourselves, I think we must conclude now. I think you have made your points extremely well.

Mr. **Dymally**. We will communicate with you and ask you some further questions. Thank you very much.

Also, at this point I should like to insert a statement for the record by Dr. George C. Pimentel, professor of chemistry, University of California, Berkeley. Dr. Pimentel was invited to be on the instrumentation panel but was unable to make it.

[The prepared statement of Dr. Pimentel follows:]

Testimony of

George C. Pimentel

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Director, Laboratory of Chemical Biodynamics
University of California
Berkeley, California 94720

Introduction

I would like to submit a statement for your consideration about the need for enhanced support of research instrumentation in the U.S. basic research enterprise. This enterprise has established the United States as the world's leader in science. It is mainly carried out in the country's Universities and it is mainly funded by the Federal Government. The advance of our fundamental knowledge is the wellspring of our technological development. Hence, the continued health of this enterprise will determine the long term economic and cultural strength of our society--as well as its security in a threatening and competetive international scene. This health is presently under stress because of inadequate resources for reseach instrumentation--the scientist's "tools of the trade."

I am a Professor of Chemistry and have been a member of the faculty at the University of California at Berkeley since 1949. I am a molecular spectroscopist, exploiting techniques that place me at the interface between chemistry and physics. I am presently Director of Berkeley's Laboratory of Chemical Biodynaics. This laboratory is dedicated to the study of processes occurring in living systems, most particularly those of photosynthesis, the processes by which energy from the sun is used to sustain all life on this planet.

I will not attempt to address the equipment needs at all levels of cost nor for all disciplines. I shall be discussing instrument needs whose item costs may presently range from $50,000 to $500,000. Such instruments, whose costs I will identify as "intermediate cost range", meet the principal research needs of quite a few subdisciplines, including such diverse areas as atmospheric sciences, chemistry, engineering, materials research, and molecular biology, among others. But before particularizing, it is worth a glance at some comparative numbers. For a useful reference point, I would like to call to your attention the proposed 1983 funding of high energy physics, whose resources are entirely federal and which come almost entirely from the Department of Energy and the National Science Foundation. Those figures are useful because physics depends heavily upon adequate funding for instrumentation development, construction, maintenance and operation.

The Proposed 1983 NSF Budget: Some Scaling Comparisons:

In the first two lines of Table I are the budgetary figures I will use as useful scaling comparisons. The first line quotes the figures given in the February 19 issue of Science Magazine.[1] It states there that the high energy physics budget would be increased from the 1982 figure of $364 million by $65 million, an increase of 17.9%. The second line lists the total budget for the Physics Division of the National Science Foundation, as proposed to you in the President's budget for NSF in 1983. Here we see that the 1982 total of $75.3 million is proposed to rise by $13.2 million, this time an increase of 17.5%. Seventy one percent of the 1983 NSF Physics Budget would be directed to Elementary Particle, Intermediate Energy, and Nuclear Physics and about half of the increase in for the development of a single instrument, the Michigan State University accelerator. These increases have been, I'm sure, persuasively won on the basis of exactly the same kinds of arguments that I wish to make to you today on behalf of many other disciplines.

The remaining lines in Table I show the proposed support of five other subdisciplines as presented to you in the President's 1983 budget for the National Science Foundation. These resources would fund the scientific efforts of about five times the number of scientists engaged in Physics.[2] It takes no specialist to recognize that within these five subdisciplines lie the underpinnings of a substantial fraction of the major technological issues facing our society. The NSF support for these crucial areas, which are mirrored in the proposed 1983 budgets of the other U.S. Agencies that also fund them, would increase by only 8.0%. I would like to try to convince you by example that these areas are in need of increases commensurate with those proposed for Physics. Furthermore, the increases are needed for essentially the same reasons: instrument development, purchase, and operational costs have soared over the last decade and they consume an increasingly large fraction of budgets that are barely keeping pace with inflation.

The example I shall present is Chemistry, the field I know best. There is no question that the picture you will see maps equally well onto Materials Sciences. I am confident that equally persuasive arguments, though perhaps different in detail, would apply to the other three fields as well.

Chemistry as an Example: Revolutionary Advances in Progress

First, a word about the state of Chemistry is appropriate. There is no scientific subdiscipline that has advanced more rapidly in the last five years than Chemistry. Let me mention only a few of the expanding frontiers to convince you that this is a considered remark.

- Investigations of chemical changes that take place on a time scale of a millionth of a millionth of a second (a "picosecond") are now active in many laboratories. One of my own colleagues, for example, is studying energy movement, step by step, in leaf chloroplasts, the molecular aggregate responsible for harvesting sunlight, moving it to a reaction center, and there storing that energy in high energy chemical bonds useful to the organism. Questions about such processes can now be answered that could not be asked a decade ago. These processes are the basis of photosynthesis.

- Backed by an arsenal of sophisticated diagnostic tools, chemists are now performing synthetic miracles, preparing and learning the behavior of new families of compounds. One of these families, the organo-metal cluster compounds, is likely to furnish a new generation of soluble catalysts. Such catalysts will furnish new and more efficient processes for a host of tasks ranging from converting coal to gasoline all the way to making nontoxic, useful products out of sewage.

- Analytical methods capable now of detection at trace levels reaching toward the parts per trillion level. These phenomenal sensitivities are giving us greater and greater ability to monitor and control the injection of potentially hazardous substances into the environment.

•The surface sciences employ a startling array of new instrumental techniques to permit detailed characterization of molecular species lodged on surfaces. At active concentrations that were barely detectable a dozen years ago, such species carry the secrets of surface catalysis, including enzyme catalysis.

•The unprecedented focal discrimination of laser spectral instruments permits spectroscopic study of subunits of living cells.

•The intensity and spectral purity of a laser light source permits the physical separation of mutant cells from normal cells at a concentration ratio of 1 in 10,000. It is easy to imagine the importance of separated mutant strains as we try to understand the molecular origins of mutagenesis and carcinogenesis.

•The recent advances dubbed "biotechnology" are dependent upon a variety of elaborate techniques by which molecular structures are determined. The computerized x-ray structural methods are now supplemented by pulse-echo nuclear magnetic resonance methods applicable to noncrystalline biological molecules. Separation techniques such as gas phase chromatography, liquid phase chromatography, and gel electrophoresis provide rapid assays that open up problems too laborious to consider a decade ago.

•There are many other examples I might have mentioned and invariably, the exceptional progress being made is attributable to the recent revolution in chemical instrumentation. The origin of this revolution is not restricted to, but is surely strongly affected by the developments in lasers and in computers. Chemistry is no longer a test tube and bunsen burner science. Chemists are using increasingly powerful and sophisticated instrumentation. This sophistication comes at a cost--that is why the resources for chemical instrumentation are so inadequate today.

Equipment Start-Up Costs for New Young Investigators in Chemistry

What is needed are some quantitative measures by which to judge the magnitude of the need. I wish to offer for your consideration some such data. First, consider Table II. It is based upon the actual equipment investments made over the last decade to permit fifteen outstanding young scientists to begin their research careers, each at a major research institution. They are based on a canvas of only a small number of institutions, but, while the number of individuals is not large, the data are not selected. All Chemistry faculty appointments at the institutions canvassed are included in the sample. There are a number of ways to analyse the data--the outcome is the same. I have chosen to present them grouped by time period into three increments, each including five Assistant Professor appointments. Thus the averages are representative of a cross-section of types of chemistry research. The dollar figure listed is the average amount of money spent for equipment to get the scientist started. In view of the difficult funding scene faced by the Universities during the seventies, one can be confident that these amounts were critically scrutinized and considered essential.

The last column shows a startling result. Over each three year period, the average investment per chemistry researcher has approximately doubled. An accurate statistical plot indicates that the required start-up equipment investment has had a 3.5 year doubling time. A smooth graph of the trend indicates that in 1983 an average of $152,000 in equipment purchases will be needed by each of our new Assistant Professors of Chemistry to begin his or her research career! This is 8.5 times larger than the amount that was being provided in 1972. Chemistry Departments simply cannot come up with this level of funding. If we care about starting new young scientists in academic research careers, federal support will have to bear the major part of the bill.

How many such appointments were made each year? Here is a way to estimate that figure. Many major reseach institutions have forty or more chemistry faculty active in reseach. (At Berkeley, my own Department, we have 53). Normal longevity indicates that each such major research institution will make about one appointment per year to maintain existing size. A useful estimate of how many such institutions to count can be taken as the number of "major departmental instrument" awards made in the NSF Chemistry Instrumentation program. Fifty such competetive awards were made in FY1981. Multiplying the $152,000 estimate by 50 requires $7.60 M to fund only these new researchers at only fifty of the front line institutions. This number is even larger than the $5.8 M figure NSF proposed to allot in FY 1983 to its Departmental Chemical Instrumentation Program, and it has been inflating at 22% per year for the last twelve years. This inflation rate shows why Physics needs its 18% increase and why Chemistry is in such intense need.

Departmentally Shared Equipment in Chemistry

Let me turn to the NSF Chemistry Departmental Instrumentation Program. This program is only a part of the NSF's support of instruments. This part is directed at the support of major equipment purchases that have departmental-wide importance and utility. Each such instrument must serve several faculty researchers. As I mentioned, fifty such awards were made in 1981. With a total budget of $5.14 M, this implies that the average Departmental major instrument grant was only a bit over $100,000, not even enough to start an Assistant Professor in research! Of all the fifty grants, the largest was about $200,000. The program depends heavily upon matching funds from the institution but that possibility is becoming increasingly difficult to arrange. Chemistry Departments are struggling to fund the operation and maintenance of the major equipment they already have and each new proposed instrument increases this ongoing burden. Physics would long ago have ground to a halt if Physics Departments were expected to match the funds on the purchase of an MSU accelerator or to provide all of the operating costs of a Stanford colliding beam storage ring.

The concept of an institutional commitment is a good one. In Chemistry, it would be reasonable to ask for 15 to 25% from the University provided this institutional commitment can be made up in part by the projected Departmental funding for operation, housing, and maintenance for the instrument. As the purchase costs for many major instruments (Nuclear Magnetic Resonance, Mass Spectrometers, Fourier Transform Infrared Spectrometers, Picosecond Lasers, etc.) are approachng or exceeding $500,000, the average NSF investment should be at least doubled from its present figure. That means that the chemistry Division budget should be increased for this purpose by another $5.8 M.

Equipment Obsolescence in Chemistry

So far, I have only addressed two aspects of the instrumentation problem in chemistry, the needs of new young reseachers and the NSF program that provides part of the resources to purchase "major instruments." We have yet to consider the ongoing instrumentation needs of the individual chemistry researchers as they adopt the latest techniques and as their existing equipment reaches obsolescence. Since I shall be telling you some facts about the NSF funding in chemistry over the last decade, you will want to know that no other U.S. Agency presently has a Departmental Instrument Program for chemistry research and the NSF furnishes about 2/3 of the federal resources directed toward chemistry research instrumentation at Universities. Table III shows the funds actually disbursed by the Chemistry Division over the time period FY 1969 to FY 1980. To smooth out year by year fluctuations, the data are again presented on a per year basis averaged over three successive fiscal years. The second column shows the funding for instrumentation, again on a per year basis averaged over three fiscal years. The last column shows the percentage of the Chemistry Division budget so expended, again on average.

Table III shows that over a twelve year period during which the NSF Chemistry Division Budget increased by an average of 9.2% per year, it has been necessary to direct a rising percentage of its funds into the purchase of instruments. In fact, the growth was doubling every three years until about 1977. At that time, the growth was deliberately moderated, on the advice of the Chemistry Division Advisory Committee, to prevent its rise above 20% of the total budget. The equipment budget, which had been rising at 26% per year, was eroding the number of active researchers who could be supported--including, most importantly, the Division's ability to fund new young scientists. If the instrument budget had been allowed to continue to rise as needed by the 26% instrument inflation rate, it would have extrapolated to $34 M in 1983, or 51% of the total proposed amount. Notice that this inflationary rate, 26%, is in rough accord with the 22% figure independently deduced from the start-up costs for new Assistant Professors. Once again, the 18% rise directed toward Physics does not seem too large.

Why is the cost of instrumentation rising so much more rapidly than the country's inflation rate over this same period? I have looked into the possibility that the cost of any particular instrument has risen abnormally. I picked at random ten instruments in my own laboratory each costing in the range $10,000 to $30,000, and purchased in the 1970-72 time period. I discovered that today's catalogues gave retail prices for the same instrument about twice as much as the original purchase price if the instrument could be found to be available for purchase. A doubling in price would correspond approximately to a normal inflation rate. However, every one of those ten instruments was considered obsolete by the scientist trying to use it. The desired replacement instrument was in every case far more sophisticated and cost far more. By "more sophisticated," I mean that its capabilities had substantially grown--usually in more than one of the performance criteria: precision, accuracy, resolution, speed of measurement, dynamic range, and reliability.

The number I have derived as the chemistry need, $34 M in 1983, represents the NSF portion only. Taking that figure as 2/3 of the total (based on the fraction of the federal support for equipment that NSF has traditionally provided), the scientific community's need can be measured at 3/2 x 34 = $51 M. That figure is so large compared to what is presently planned, that I would like to examine what it means in terms of obsolescence.

The rapid advance of instrument development causes obsolescence to be determined by technological advance, not mechanical failure. In fact, it has been estimated in the AAU study of the country's instrumentation needs that technological obsolescence gives an instrument a 5-7 year lifetime today.[4,5] We can use the upper limit of that lifetime to get a separate estimate of what the equipment budget ought to be.

First, there are about 15,000 chemists employed on University or College faculties.[6] About 4000-5000 of these are placed in major research Universities. I would like to assume that about half of them, say about 2250, are active in reseach. This estimate that can be seen to be reasonable by the fact that the NSF supports about 1500 chemists in Universities[2] while disbursing about 25% of the federal research funds going into University reseach in chemistry. If, in fact, there are 2250 active chemists and each has equipment that becomes obsolete every seven years, then one seventh of this number (320) will need new equipment each year. If the total federal equipment budget for chemistry were $51 M in 1982, then each scientist would be provided, on the average, $51 M/320 = $159,000. This is just about equal to the $152,000 cost of start-up for a new young Assistant Professor and close enough to corroborate the reasonableness of my figures. Of course, a portion of this need (perhaps half) will be met by an adequate Departmental Instrumentation budget.

The Magnitude of the Need

Now I should remind you that I have been estimating the equipment needs of only the chemistry part of our scientific community. At the beginning of this discussion I indicated that there were at least four other subdisciplines with rather similar instrument needs in the "intermediate cost range" (i.e., $50.000 - $500,000). Even if these scientific communities are somewhat smaller than the chemistry endeavor, it is easy to see that an annual and continuing federal equipment budget of $100 M for instruments in this cost range can be justified.

You can see, I believe, the dilemna facing our science funding agencies, especially NSF. Without additional money for instrumentation, a program officer must decide on some mix of reducing the number of productive scientists who will receive any support at all and reducing the effectiveness of the ones who are supported by not providing them adequate instrumentation: With any choice, the result is one the United States cannot afford. There will be a continuously decreasing number of scientists who will be able to compete on the international scene. Our ability to stay at the forefront will decline in atmospheric sciences, chemistry, engineering, materials science, molecular biology, and many other disciplines. Even if Mr. Keyworth's admonition that "We can't expect to stay ahead in everything" were reluctantly accepted as an operating doctrine, he would not wish and the country cannot afford to mortgage its future by letting Mr. Keyworth's doctrine to be paraphrased into "We will plan not to keep up in anything." We won't keep up unless our scientists have the latest equipment. There is no reasonable basis on which to argue that a need of the magnitude I have outlined will be available from industry. The federal government must meet this pressing need.

A Proposal

It is my understanding that the Department of Defense has proposed to earmark $30 M from its 1983 funds for reseach equipment purchases, presumably for instruments in the "intermediate cost range." I urge that the Congress add $70 M more to the 1983 NSF budget with the recommendation that it be used to alleviate the equipment needs of those scientific disciplines whose equipment needs fall in the "intermediate cost range."

Thank you for this opportunity to present this testimony. I request that it be placed before the Subcommittee on Science, Research and Technology and in the Congressional Record.

Table I

Some Budget Proposals[1,3] for Research Funding in 1983

	1982 Budget	Proposed Increase in 83	% Increase, 1983/1982
High Energy Physics (DOE)[1]	$364 M	$65 M	+ 17.9%
NSF Physics Division[3]	75.3 M	13.2 M	+ 17.5%
	$439.3 M	$78.2 M	+ 17.8%
NSF Atmospheric Sciences[3]	$ 70.0 M	$ 4.8 M	+ 6.9%
NSF Chemistry Division[3]	60.7 M	5.4 M	+ 8.9%
NSF Engineering[3]	92.0 M	7.7 M	+ 8.4%
NSF Materials Research Div.[3]	74.5 M	6.4 M	+ 8.6%
NSF Molecular Biology Div.[3]	79.4 M	5.8 M	+ 7.3%
Totals	$376.6 M	$30.1 M	+ 8.0%

Table II

Average Equipment Purchases Made for New Assistant Professors of Chemistry

Time Period	Number of Individuals	Average Investment per Individual
1970-73	5	$14,576
1974-76	5	32,686
1977-1980	5	64,455

Table III

Chemistry Division
N.S.F. Funding of Research Instrumentation

Fiscal Years	Instrumentation Costs (Av/yr)	% of Chem. Div. Budget Spent for Instrumentation
FY 1969,70,71	$1.5 M	8%
FY 1972,73,74	3.5 M	14%
FY 1975,76,77	6.5 M	18%
FY 1978,79,80	8.5 M	18.5%

References

1. Quoted in Science Magazine, Vol. 215, p. 947, February 19, 1982.
2. For example, the NSF FY 1980 Budget Book to Congress indicated that the NSF Physics Division supported 1205 scientists while making 359 grant awards. The three NSF Divisions, Materials Research, Engineering and Chemistry supported 3780 scientists while making 2554 grant awards.
3. NSF FY 1983 Budget in Brief as presented to Congress, January, 1982.
4. See lifetime estimates presented in the AAU document "The Nation's Deteriorating University Research Facilities"(July, 1981), Appendix 2, "Chemical Sciences," p.4, p.6.
5. See AAU document "The Scientific Instrumentation Needs of Research Universities" (June, 1980),p. 13. It shows that the average age of the instrumentation in industrial research laboratories is 3.6 years.
6. "Professionals in Chemistry 1979-1980," American Chemical Society (March, 1981), see p.32.

Mr. **Dymally**. The meeting is adjourned.

[Whereupon, at 12:45 p.m., the subcommittee recessed, to reconvene at the call of the Chair.]

[Additional material submitted for the record follows:]

Replies by S. M. Pfafflin to questions asked at the March 4, 1982 hearing of the Science, Research and Technology Subcommittee

Question: Could you expand on some of the problems you have observed in women's programs outside of NSF?

First, let me clarify a point; in my testimony, I was not referring to programs targeted specifically to women. So far as I am aware, there are no federal programs targeted specifically to women scientists outside of NSF. However, there have been several recent initiatives intended to provide various kinds of support for science education. While these programs are not targeted to specific groups, they cover many of the areas addressed by the Science Education Directorate at NSF. These programs include those of the Defence Communications Agency, which has undertaken a program to mobilize private support for efforts to attract high school students to careers in science and engineering, and fellowship programs in specific areas, such as the Office of Naval Research fellowships being administered by the American Society for Engineering Education.

The reasons for concern, as regards the participation of women, is that the programs may be administered in ways which will tend to exclude women. Programs designed for general audiences can be effective in attracting young women to careers in science and technology, but both the materials and their delivery must be carefully planned to appeal to both sexes, and this takes experience and motivation which are often lacking. The Army record in this regard is hardly reassuring; they have been responsible for the wide dissemination to high schools of a vocational aptitude test with adverse impact on girls. In the case of the DCA, their effort is, initially at least, being developed through the ROTC high schools, and, in the materials we saw intended for highschool students, the scientists and engineers were virtually all male. While those I have spoken to connected with the program indicated their desire to include individuals from all groups, it is nevertheless a matter of concern that the major federal initiative in this area at the present time should be coming from defence agencies which lack the expertise and perspective which has existed at NSF. There is a serious question as to whether they have the capability to develop programs which will reach women and minorities effectively.

With regard to the fellowship programs, while these might attract many women applicants in the right circumstances, given the military sponsorship and the non-traditional fields, it may be necessary to go to some lengths to reach qualified women and make it clear that applications from them would be welcome. Simply using the usual distribution channels is not enough; these depend too heavily on individuals and organizations many of which are indifferent or hostile to the entry of women into their fields. I question whether the necessary effort is being made to reach women effectively.

One may also question whether it is a sensible strategy to disband the Science Education Directorate, which has considerable expertise in these areas, while funneling large amounts of money into similar activities through a number of ad hoc channels. For example, the experience gained with the career guidence programs for women students has general aplicability for programs to encourage careers in science and technology for all young people, and it seems inefficient to dismantle them and start over. The loss of trained professional staff during the recent reductions in force at NSF represents a loss of expertise which is not easily replaced.

One unusual aspect of the DCA undertaking is the effort to obtain funding and other kinds of involvement from industry. There seems to be no reason why NSF could not undertake efforts to organize support for its programs from outside sources, which would combine the advantage of utilizing existing expertise while increasing support from nongovernmental sources.

In his report to the Congress last year on actions being underrtaken by NSF to increase the participation of minorities and women in science and engineering, Dr. Slaughter stated that "...it is imperative that the Foundation coordinate its efforts, experience, and resources with those of other sectors to increase the participation of minorities and women in science and engineering." This area would provide a good opportunity for implementation of that statement. Not only is there expertise at NSF, but NSF could undertake to encourage the utilisation of the procedures developed through WEEA to the areas of science and technology in a cooperative effort with other government agencies and other sectors.

Question: We have heard a great deal about the effectiveness of the reentry programs. Is there a substantial pool of women available for these projects?

Answer. Dr. Vetter, Executive Director of the Scientific Manpower Commission, has estimated on the basis of the number of degrees granted to women, and their present participation in science, that the potential pool exceeds 500,000. While not all of these women may wish to participate, the substantial interest in the reentry programs shows that many of them do.

Eventually, it is to be hoped that we can correct the problems which lead to the existence of this pool of underutilized talent. However, at present, it exists, and will continue to do so for some time. The administration position seems to amount to saying, yes, there is a need, and, yes, we have a cost-effective solution so we are going to stop funding that solution. It doesn't make sense.

I have been told that some engineering educators have been reluctant to encourage retraining programs; they allege that participants frequently return to their original occupations as soon as opportunities open up. However, this objection does not hold for programs such as the NSF reentry programs. Very few, if any, of the participants in the reentry programs would return voluntarily to their previous occupations, since, if they had been employed, it was usually in jobs with far poorer pay and career prospects than those opened to them by the reentry programs.

Here again, we have an opportunity for NSF to implement the principles Dr. Slaughter expressed in his report. NSF could undertake efforts to seek funding for these programs from other sectors, promote these programs withing the engineering education community, and dispel any misunderstandings regarding their usefulness.

What kinds of actions can granting agencies take to improve the status of women in the nation's universities?

Answer: There are a number of specific actions which could be taken. It should be recognized that the program directors have a good deal of influence thru their administration of grants. When such individuals are sensitive to the problems which face women scientists, and willing to try and deal with them they can have a positive effect. Beyond this, the granting agencies can establish policies encouraging elimination of barriers to grant applications by staff not in tenure-track positions. This might be done by monitoring research proposals, for example, and making it clear that those proposals in which the PI is also the person primarily responsible for carrying out the research will receive favorable consideration in the case of otherwise meritorious proposals. The addition of small amounts of money to grants which employ women graduate students as research associates in those fields where women are greatly underrepresented would be helpful. Some extra funds for research, even in small amounts, to universities which are above average in the number of women PIs and the number of women faculty especially the number of tenured women faculty, is another possibility. Granting agencies could participate in efforts to find positions for women faculty in cases where women are in very low numbers in a given field. The proposed roster of women scientists at NSF could provide the basic information necessary for such a system.

It should not be assumed, however, that the steps needed to increase the participation of women in science and technology and achieve equal career opportunities for them can be implemented fully without targeted programs. While the Visiting Professorship program is a welcome initiative, it is a very small program, and much more is needed. As I stated in my testimony, programs of direct support, such as the National Research Opportunity Grants are needed. A program of graduate fellowships for women students in fields where the numbers of women are very low is also needed. It will take decades to substantially increase the numbers of women faculty in some fields unless the numbers of women doctorates can be increased. In these circumstances, the loss of three-quarters of the funding for women's programs at NSF is a matter for grave concern.

Question: Dr. Slaughter made a number of committments to this committee late last year on "in-house" actions he would be taking at the foundation. What is your opinion of his proposals?

Answer: I would agree with Dr. Slaughter that there are a number of useful things which the granting agencies can do through "in-house" efforts, and many of the actions which he proposes can be of substantial value. Let me comment specifically on some of them.

The importance of equal opportunity recruitment efforts for NSF staff is obvious, and NSF has mechanisms in place for this activity. It is equally important for the review process, and steps to increase the numbers of minorities and women are welcome. It is perhaps too early to determine their overall effectiveness. However, it is not too early to examine progress on specific projects, such as the proposed development of a roster of women scientists and engineers. Has responsibility for this project been assigned? Have contacts been made with NIH, which has a roster of minorities and women in the biological sciences, or with organizations of women scientists, such as the Association for Women in Science, which have registries and rosters? Information on this would indicate the vigor with which these efforts are being pursued.

Staff orientation is also important, and efforts to increase the number of grants by minorities and women, and to provide technical assistence in the preparation process are certainly worth pursuing. However, efforts directed solely to the women themselves do not address some of the most serious problems. As I have indicated elsewhere, efforts need to be directed to the universities to change policies which inhibit women from applying for grants, and there is a need for awareness of the problems facing women scientists by those who administer grants. The proposal to have key staff from colleges and universities concerned with minorities and women come to NSF could be of value. However, in the past, the colleges which have traditionally served women have often been ignored in such programs. These schools need to be included. As far as other institutions go, efforts are needed to improve sex equity in their science and engineering programs, as well as to familiarize them with NSF procedures. I would hope that any efforts undertaken in this area would include that component. Here again, in addition to sharing NSF's experience, the results of WEEA and other relevant government efforts should be disseminated.

Data collection activities are very important. Without adequate data, we cannot determine where we succeeding and failing, and cannot direct resources effectively. Such efforts are especially important in view of the radical decrease in funding for efforts to achieve sex equity in education. Many of these efforts were in areas important for increasing the participation of women in science, and their loss can have serious adverse impact on the entrance of women into science and engineering. In view of the decreased emphasis on enforcement of equal opportunity in employment, there is a strong possiblity of adverse effects in the employment areas as well.

I would hope that Dr. Slaughter's comments on proposal selection criteria would extend to considering not only the sex of the PI but the importance of the research with regard to women, including women in science, where this is appropriate. Again, with the loss of funding for research in the behavioral sciences, and in areas important for achieving sex equity in education, it is important that whatever research remains be effective, and it can hardly be that if it ignores half the population. I would suggest that all research funded in the behavioral sciences be examined to determine whether the populations it studies includes women, and whether it is designed so that its results are applicable to them.

The principles given in the section on other sectors are excellent, and there are many opportunities for the implementation which would be of great value to women scientists, some of which I have indicated above. However, I wonder where the resources are going to be found for implementation? Much of the expertise required was located in the Science Education Directorate, which is being phased out.

A crucial element in Dr. Slaughter's recommendations is the effectiveness of the implementation, and while this is always of importance, it is especially critical for actions which are implemented through the research directorates without specific programs, because their success depends so heavily on the actions of a great many people, all of whom have many other responsibilities as well. This is in contrast to the targeted programs, where specific individuals have implementation as a primary responsibility, and are provided with resources to carry them out. NSF is to be congratulated on preserving so many of the programs for minorities, and finding the resources for additional initiatives for minorities and women. However, the loss of three-quarters of the funding for programs for women, and the elimination of the two pre-existing programs is a serious blow to efforts in behalf of women in science. While the new visiting professorship program is a significant contribution, as I noted before, the resources going into it are very limited, and there are other important needs which have not been met.

There are many dedicated individuals at NSF who can contribute effectively to implementation through the directorates, and there have been a number of constructive suggestions and actions already taken by some of the directorates; these are encouraging signs. However, it is early to say how effective the results will be, or to determine whether they can be sustained over time.

This raises the question of monitoring. It is clear that attitudes which are inimical to women in science are far from dead. Over the past several months, reports of the resurgence of sexist attitudes in the scientific community have reached alarming proportions. Since the professional personnel at NSF are drawn from this pool, it is reasonable to assume that some of these attitudes persist there also. For example, views that, in times of decreasing financial support for scientific research, married women should receive less consideration than men because their husbands will continue to support them, are, unfortunately, still with us, and, given the freedom which program directors have to choose between projects of similar merit, such attitudes could have very adverse impact on women scientists in programs they manage. Given the large numbers of program directors, and the difficulty of detecting such biases in small samples of decisions by purely statistical approaches, it is important that there be systematic reviews of grants, especially those involving women and minorities, to insure that individual cases are being handled fairly.

Generalizing from this, I think it will be important to monitor all proposed actions to insure their effective implementation, and to provide some additional support for those who undertake the initiatives suggested by Dr. Slaughter, if sustained progress is to be made. Implementation of the proposal for supplemental funding is very important, therefore, and should include this component. For example, travel funds are now very short at NSF. If travel which combined other business with some of the initiatives suggested in Dr. Slaughter's report could get additional funding, it would help program budgets and encourage these initiatives. Similar ways could be found to support other suggestions.

With regard to their effectiveness in behalf of women, I believe that further initiatives will be necessary if the most serious problems facing women scientists are to be addressed effectively. I have suggested some directions these initiatives might take, but I would like to add that NSF, like many other granting agencies, has been reluctant to take any action which might be construed as affecting how the univesities treat their staffs. They have bent over backwards in this matter, although, in other ways, such as their funding priorities, the granting agencies have enormous impact on colleges and universities, and they consider this entirely natural and proper. The granting agencies could do far more than they have done, and than is proposed in Dr. Slaughter's report, and I think they will have to do so if we are to maximize our utilization of our human resources in science and technology. Increased concern about the status of the non-tenure track research staff is a problem which has been recognized for a long time, and which affects both men and women scientists, though it is especially critical for women. It is time that it was addressed by the granting agencies; their money created this class of scientific worker, and they should accept responsibility for them to a greater extent than is presently done.

One other concern is the extent to which Dr. Slaughter's proposals will be taken to apply to women. Despite the size of the pool of potential women scientists, it has proved to be curiously difficult to convince the scientific community that serious efforts should be undertaken to utilize them.

If one examines the performance of many programs where women are included as one of several groups, it usually turns out that the proportion of program resources devoted to women is very small; in proportion to the potential pool, it is apt to be minuscule. NSF has run true to form in this respect in the past, and may be continuing to do so. For example, if one examines its equal opportunity activities, the leading positions, especially those involving outreach, are usually held by males. Women, when present, tend to be in subordinate positions. Since a great deal of the success of equal opportunity efforts depends on the perceptions which the program staff has of the agency's priorities, these signals can be important. The 75% cutback in funding of women's programs for 1982 over 1981 may also give rise to questions about the seriousness of the agency's efforts with regard to women. To date, NSF has failed to build a solid capability to deal with the issues of women in science, nor has it developed effective communication with its constituencies in the scientific community on this subject. There are many individuals within NSF who have both the expertise and the motivation to contribute to a successful effort, and there have been positive steps, including the formation of the Committee on Equal Opportunities in Science and Technology, but NSF is still far having the required capabilities now. While I believe that Dr. Slaughter's recommendations can be effective steps towards reaching this goal, it remains to be seen whether they will be effectively implemented for women scientists.

Massachusetts Institute of Technology

Biomechanics and Human Rehabilitation

an excerpt from the ANNUAL REPORT ACADEMIC YEAR 1980-1981 DEPARTMENT OF MECHANICAL ENGINEERING

This excerpt provides a synopsis of current research activity relating engineering to the rehabilitation of humans with sensory, motor, and skeletal disabilities.

A "Project Bibliography on Technology and Rehabilitation," available from the office above lists all publications of the program dating from 1960 to the present.

Robert W. Mann, Whitaker Professor of Biomedical Engineering, Room 3-144, MIT

Eric P. and Evelyn E. Newman Laboratory for Biomechanics and Human Rehabilitation

Technology designed to rehabilitate handicapped humans, based on fundamental understanding of the underlying physiology and biomechanics, constitutes one of the major foci of biomedical engineering research in the Mechanical Engineering Department.

Beginning in the early 1960s, the challenge of natural control of an artificial limb following amputation motivated Professor R. W. Mann's pioneering work on the "BOSTON arm," now commercially available from the Liberty Mutual Insurance Company. In his doctoral thesis, S. C. Jacobsen, now on the faculty at the University of Utah, extended cybernetic control of an upper extremity prosthesis to include the shoulder and wrist joints as well as the elbow; the "UTAH arm" is approaching manufacture by Movement Control Inc. R. B. Jerard, now on the Dartmouth faculty, followed his "BOSTON arm" thesis with a doctoral thesis under Professor Jacobsen on the "UTAH arm." N. Hogan, who did his SM and PhD theses on limb prosthesis control, is currently on the MIT faculty, where he is incorporating into prostheses higher-fidelity interpretation of the human myoelectric signal and more physiologically sound muscle mechanics. W. C. Flowers, also on the MIT faculty, who started the "MIT knee" as his PhD thesis, is focusing on more responsive and adaptable lower-extremity prostheses.

Thus, over the past two decades, the group has combined innovative engineering design with sound physiology and biomechanics to create what are probably the most advanced, naturally controlled artificial limbs existing. As an integral part of the design process of achieving functional hardware, unique and sophisticated computer-based protheses simulation systems have been developed, dramatically improving the electronic acquisition of biological signals and contributing to fundamental neurophysiological understanding of human movement control. During these same two decades, research on, and the design of, communication and mobility aids for the blind and physically handicapped progressed from thesis studies to practical use as outlined in the complementary description of the Sensory Aids Center. Thus, in the reciprocal synergism so characteristic of the MIT style of combining education and research, the group's progress has been achieved, in the main, through the exceptional graduate and undergraduate theses and UROP projects of many students as attested to by the 159 theses in the Technology and Human Rehabilitation Bibliography.

During the 1970s, the original focus on amputation and prostheses broadened into more comprehensive studies of the normal and pathological human neuromuscular system, with the added goal of the diagnosis and therapy of muscular, skeletal, and joint malfunctions. Each project active in the Laboratory is outlined later in this Report.

This past year we have benefitted by significant physical changes in the Laboratory. A major gift from Eric P. and Evelyn E. Newman finally realized a planning process which goes back over a decade. The prime laboratory space centered in the Mechanical Engineering Department on the first floor of Building 3, which was originally the Department's Heat-Power Laboratory and then became the Engineering Projects Laboratory, is now the Eric P. and Evelyn E. Newman Laboratory for Biomechanics and Human Rehabilitation, named after out benefactors. Mr. Newman graduated from MIT in 1932.

Experimental and fabrication facilities in the Building 3 Laboratory are adequate to subsume the Laboratory group's activities now resident in the Sensory Aids Center in Building 31, when adequate office space for staff can be arranged. The new mezzanines, possible because of the high headroom of the first floor of this 1917 building, not only created the equivalent of five bays of new floor area, but also provide excellent office space for graduate students, achieving both adequate privacy and easy surveillance of the laboratory space below.

The Mobility Facility is the center of human-posthesis and musculoskeletal and joint research, and is equipped with novel and versatile instrumentation by which human movement can be monitored. The precision of the instrumentation is such that ordinary undulations in the floor proved deleterious. A grant from The Lillian Babbitt Hyde Foundation permitted leveling the Mobility area to high precision.

Adequate computer facilities are essential to the Laboratory, not only in the ubiquitous manner computation invades all analysis, but also in the special way computers are used in human-prostheses interaction, in gait and mobility studies, and in the simulation of travel aids for blind persons. The new laboratory expansion was aided by being able to add to the existing PDP 11/40 a much faster, larger-memory, multi-user Digital Equipment Corporation PDP 11/60. These two machines are now DECnetted together and subsequently both of them will be linked with the Joint Computer Facility PDP VAX 11/80 in order to handle really large computational tasks.

With the newly renovated space, equipment and facilities, and building on the past accomplishments and current research activities, the laboratory group now stands as probably the premier activity applying technology to the amelioration of human physical handicaps.

Research in the Eric P. and Evelyn E. Newman Laboratory for Biomechanics and Human Rehabilitation is supported by the National Institutes of Health of the Department of Health and Human Services, the National Institute of Handicapped Research of the Department of Education, the National Science Foundatin, the Veterans' Administration, the Whitaker Professorship of Biomedical Engineering, the Whitaker Health Sciences Fund, the Kroc Foundation, and the Sloan Fund for Basic Research.

Sensory Aids Center

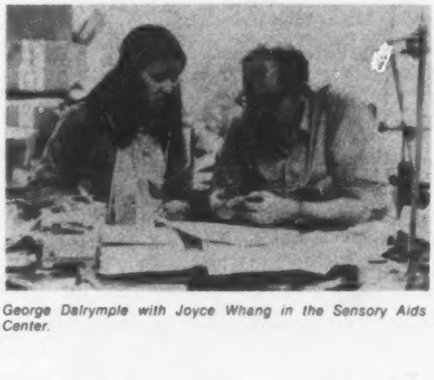
The MIT Sensory Aids Evaluation and Development Center was created in 1964 to bring new technology to the assistance of handicapped people with sensory deficits. The initial emphasis was upon assistive devices for the blind, and over the years the Center has undertaken pioneering work in the development, evaluation, and dissemination of electronic and mechanical aids to the mobility, vocational, and reading problems of the blind.

Recently the Center's Director, Professor D. Rowell, and Professor R. W. Mann have expanded the activities of the Center to include systems that will address problems of both motor and sensory handicaps. Some new areas of research and development include the study of the information acquisition and display for effective mobility of the blind, prosthesis position display schemes, devices for the suppression of vocal stutter, the development of communication methods and environmental control systems for the non-verbal motor impaired, and a refreshable braille display for the blind telephone switchboard operators. Several of these devices are now in commercial production or are at the stage of technology transfer.

All of these projects embrace a common problem, the design of an alternate information display to augment a severely impaired sensory channel. As a general design philosophy, the Center attempts to use psychophysical experimentation and computer-based simulation to evaluate the potential of proposed systems. The behavioral responses of human subjects to new forms of information display in dynamic experimental tasks are used to provide specifications for hardware systems. Students and staff subsequently design, build and evaluate the designs.

The Center actively supports educational institutions and rehabilitation agencies in their efforts to make technological innovation available to the handicapped. This has recently included assistance with postgraduate courses in electronic systems for the blind at several universities, and assistance to agencies introducing new devices.

The National Institute of Handicapped Research of the Department of Education has been the primary sponsor of the Center. Private foundations — the Hartford and Zeigler Foundations, Seeing Eye, Inc., United Cerebral Palsy, Inc. — sponsor individual projects as do agencies dedicated to rehabilitation, such as Arkansas Enterprises for the Blind and Creative Technological Aids, Inc. Income derived from the Germeshausen and Whitaker Professorships has also supported specific efforts at the Center.



George Dalrymple with Joyce Whang in the Sensory Aids Center.

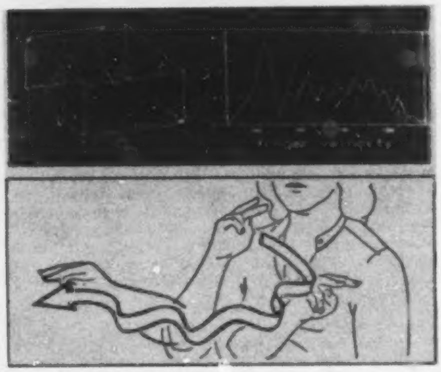
Human Rehabilitation

A Data Acquisition System for Kinesiological Studies

Professors R. W. Mann, D. Rowell; E. K. Antonsson
Sponsors:
Whitaker Professorship of Biomedical Engineering, National Institutes of Health, Newman Laboratory Fund

Many biomechanical, sensory aid, and rehabilitation studies require the measurement of the spatial trajectories of various parts of the human body. Telemetered Real-Time Acquisition and Computation of Kinematics, a general purpose laboratory system dubbed TRACK, automatically acquires, manages, and displays 3-D kinematic data from up to 10 moving bodies. Translations of individual segments are measured in an absolute reference frame to within 1 mm and rotations within 1 degree in a 3-meter viewing cube. For real-time computation, data from several segments can be sampled at 30 Hz, while for off-line processing the sample rate is 315 Hz.

Data input to a Digital Equipment Corporation PDP 11/60 minicomputer via direct-memory access (40,000 words/sec) is from the Selspot System which is comprised of 30 time-multiplexed, deep infrared LED's and two cameras whose image planes are lateral photo-effect diodes. Each body segment carries an array of at least three LED's mounted on a plane. The TRACK software first calculates the X-Y-Z position of each LED; then aggregates LED's common to an array; calculates the RMS position of the array; defines that as the array coordinate origin; and then calculates the vector defining the array plane. Since the translational and rotational time histories of adjoining linked segments are known in the absolute coordinate system, the common center of rotation can be calculated frame-by-frame. Precise knowledge of this location is especially important to subsequent dynamic analysis. Lagrangian interpolation preceded and followed by sixth-order Butterworth filtering produces linear and angular velocity and acceleration data for each segment. Extensive graphic interaction capability facilitates operation and interpretation of experiments and several kinematic data display and plotting routines can be exercised.



Sign language for "look at each of them": sketch of actual hand trajectory below; computer graphics display of 3-D trajectory above left and finger velocity above right.

The TRACK system has been applied to human/computer interactive research on limb and sensory prostheses, hypotheses on the cognitive basis of sign language and visual perception and kinematic studies of human movement.

This past year's effort included a new and more thorough calibration procedure that brings all system geometry errors and nonlinearities to within 1 discretization bit out of 1024. By DECnetting the PDP 11/60 and the 11/40, the full graphics potential of the latter is linked to the speed and capacity of the former.

Recent Publication:

R. W. Mann, D. Rowell, F. Conati, A. K. Tetewsky, E. K. Antonsson, "Precise, Rapid, Automatic 3-D Position and Orientation Information from Multiple Moving Bodies," *VIII International Congress of Biomechanics*, Nagoya, Japan, July, 1981.

Feasibility Study for Interactive Ballet Theatre Set with Visual Projection Mimicking the Dancer

Professor R. W. Mann; A. R. Marion, E. K. Antonsson
Sponsors:
Joffrey Ballet, Inc., MIT Council for the Arts, Whitaker Professorship of Biomedical Engineering

An added aesthetic dimension to ballet would be concurrent optical projection on the theatre set of the body image of the dancer. Our TRACK kinematic data acquisition system will be investigated as a possible source of input data, derived from light-emitting diodes mounted on the dancer. Following transformation in a computer, the body imagery would be displayed via an appropriate two-dimensional moving picture device.

The goal is both an aesthetically pleasing synergism of dancer and image and a system easily used by both dancer and choreographer. The potential and flexibility of such a choreographic "tool" could add new dimensions to the experience and performance of the Dance.

The Derivation and Implementation of a Three-Dimensional Dynamic Analysis Technique

Professors R. W. Mann, D. Rowell; G. F. Dalrymple; E. K. Antonsson
Sponsors:
Whitaker Professor of Biomedical Engineering, National Institutes of Health, Newman Laboratory Fund

The kinematic data provided by the Mobility Facility's TRACK system is used to obtain estimates of skeletal joint moments and inertial reaction forces in the mobile human. The data available are the absolute three-dimensional positions and orientations of each of 10 or fewer body segments. The relative position of any segment with respect to any other segment is used to locate the instantaneous axis of rotation between any two segments. Dynamic equations relate these motions to the inertial forces and moments required to produce gait, with the assumption that the limb segments are rigid. This then becomes a three-dimensional linkage analysis problem. The force/moment estimator, dubbed NEWTON, produces very favorable results with both ideal data and with actual kinematic data as illustrated by analyses of and experiments with a two-degree-of-freedom pendulum of known inertial properties. NEWTON is general enough to accept linkages of any complexity and connectivity. For an open assemblage with ten or fewer links, the system provides complete dynamics. In assemblages of more than 10, the human body for example, a reference force and moment must be available somewhere along the linkage. A three-axis force plate installed in the Mobility Facility floor is linked to the PDP 11/60 via a digital direct memory access interface with remote 12 bit digitization of the analog voltages. This approach increases the signal-to-noise ratio and allows simpler software for accumulation of simultaneous force plate and Selspot data at the full frame rate of 315 Hz.

A study has been initiated to determine the frequency domain characteristics of the entire TRACK/NEWTON measurement system to determine the limits of confidence on the end result of kinematic as well as dynamic data.

The TRACK/NEWTON system has estimated articulation forces and moments which in turn have been applied to musculoskeletal models of the lower extremity to identify optimization criteria in human movement and to determine the time course and amplitude of individual muscle action.

Recent Publication:

E. K. Antonsson, R. W. Mann, "Quantitative Three-Dimensional Dynamic Analysis of Human Movement," presented at the 8th Annual Northeast Bioengineering Conference, Cambridge, Massachusetts, March, 1980.

Ultrasonic Location of Bone During Human Gait
Professor R. W. Mann; D. B. Pape
Sponsors:
Whitaker Professorship of Biomedical Engineering, UROP

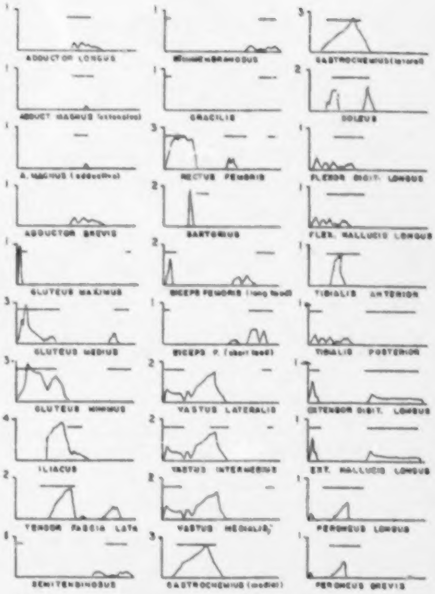
Determination of the kinematics of human movement, as with the TRACK and NEWTON systems described above, requires knowledge of the inertial properties of body segments and the location of centers of gravity and moments of inertia relative to the external-to-the-body kinematic data reference frame. A ubiquitous problem in all gait studies is skin and muscle tissue movement during movement. For our TRACK system the external frame is multiple, coplanar LED's supported by a Velcro® strap around the body segment. This project is exploring the feasibility of dynamic dimensional referencing of the LED plane to the long bone of the body segment by sampling the distances from skin to bone around the perimeter of the body segment using ultrasound transducers integrated into the straps supporting the LED's.

An analytic feasibility study in a Bachelor's thesis last year was followed by a UROP project in which actual ultrasonic measurements were made *in vitro* on a human femur suspended in a water bath to simulate soft tissue. Translations of the bone relative to the skin are easily discerned, but detection of relative rotation can be ambiguous.

Recent Publication:

D. B. Pape, "A Feasibility Study for Ultrasonic Detection of Bone Location During Human Gait Studies," Undergraduate Research Opportunities Program, MIT, Mech. Eng., August, 1980.

Prediction of Muscle Forces During Human Movements
Professors R. W. Mann, D. E. Hardt; Dr. S.R. Simon (Children's Hospital Medical Center); A. G. Patriarco
Sponsors:
Whitaker Professorship of Biomedical Engineering, National Institute of Handicapped Research - Department of Education, National Science Foundation, Whitaker Health Sciences Fund Fellowship, Newman Laboratory Fund



Individual muscle activity in walking: curves are amplitude versus time predictions of muscular skeletal model: bars are experimental myoelectric records.

In human movement studies, the analysis of limb dynamics is limited to those quantities which can be derived from external measurements of motion and mass distribution. This permits external joint moments to be calculated (as with TRACK/NEWTON) but tells nothing of those components of internal muscle forces which combine to provide equilibrating torques. Knowledge of these individual muscle forces is essential, for example, in clinical fields such as reconstructive surgery and in research areas of joint mechanics and motor neurophysiology.

Unfortunately, these forces cannot be calculated directly, due to the redundant muscle arrangements about the joint, nor can they be measured by non-invasive means. To circumvent these problems, we have been conducting optimization studies with different constraints on a 31-muscle, 7-degree-of-freedom model of the human lower extremity. The accuracy of analytical predictions is evaluated by comparing the model predictions of the amplitude and timing of individual muscle action with myoelectric signals from accessible leg muscles collected simultaneously with the kinematic data and foot-floor forces in gait.

In a study comparing kinematic data from two different sources, our TRACK system and the Children's Hospital Gait Analysis Laboratory cine system, the accurate determination of joint angles and calculation of joint torques was shown to be more crucial than the particular optimization criteria employed. Appropriate constraints improved correspondence between the model prediction and the experimental myoelectric signals, but predictions about the ankle joint were inferior to those about the knee and hip.

Recent Publications:

D. E. Hardt, R. W. Mann, "A Five-Body, 3-Dimensional Dynamic Analysis of Walking," *J. of Biomechanics*, 13, No. 5, 1980.

A. G. Patriarco, R. W. Mann, S. R. Simon, J. M. Mansour, "An Evaluation of the Approaches of Optimization Models in the Prediction of Muscle Forces During Human Gait," *J. of Biomechanics*, 14, No. 8, 1981.

A. G. Patriarco, D. E. Hardt, R. W. Mann, S. R. Simon, J. M. Mansour, "An Evaluation of the Approaches of Optimization Models in the Prediction of Muscle Forces During Human Gait," presented at the Rehabilitation Engineering Society of North America Meeting, Washington, D.C., September, 1981.

Biomechanics of the Ankle and Foot

Professors R. W. Mann, D. E. Hardt; Dr. S. R. Simon (Children's Hospital Medical Center); A. G. Patriarco, C. C. Awh
Sponsors:
Whitaker Professorship of Biomedical Engineering, National Institute of Handicapped Research - Department of Education, National Science Foundation, Whitaker Health Sciences Fund Fellowship, Newman Laboratory Fund

The partitioning of ankle force and torque among the participating mucles via optimization analysis has prompted the design of an ankle-specific test apparatus, now under construction, which will expand our knowledge of the functional anatomy and physiology of the ankle musculoskeletal system. Computer mediated exercise of the joint over its three-dimensional physiological range, with concurrent TRACK kinematic and myoelectric signal acquisition should lead to improved models of the ankle joint which will then be factored into an overall leg model.

Recent Publication:

C. C. Awh, "Biomechanics of the Ankle and Foot," SB Thesis, Dept. of Mech. Eng., MIT, June, 1981.

Neurophysiological Feedback from Extremities

Professor N. Hogan; W. R. Murray, P. S. Hamilton
Sponsor:
National Institute of Handicapped Research —
Department of Education.

The goal of this project is to improve the forward-path fidelity of myoelectrically-controlled assistive devices. Typical myoelectric controllers are inaccurate and require the operator to compensate by using external feedback, typically visual or auditory. This increases the mental workload placed on the operator to the extent that it can offset the device's improved functional capabilities. Our aim is to provide a forward path of sufficient accuracy that the operator will be able to use the inherent proprioception of muscles to provide him with necessary knowledge of outgoing commands, thus reducing his dependence on external visual and/or auditory feedback.

In the past year, an improved myoelectric signal processor design has been implemented using microprocessor technology. This device is capable of sampling four channels of myoelectric activity simultaneously at 500 Hz, and combining these signals to produce a single estimate of muscle force. A particular advantage of digital implementation is that calibration has been vastly simplified and can be performed automatically.

Implicit in the design of the forward path are assumptions about the strategies of motor control available to the operator. An investigation has begun which will use the concept of end-point impedance control to classify movement tasks, particularly those involving mechanical interaction with the environment, and to quantitatively assess the ability of a given forward-path design to perform this task.

Recent Publications:

N. Hogan, R. W. Mann, "Myoelectric Signal Processing: Optimal Estimation Applied to Electromyography. Part I: Derivation of the Optimal Myoprocessor. Part II: Experimental Demonstration of Optimal Myoprocessor Performance," *IEEE Transactions of Biomedical Engineering*, July, 1980.

L. M. Deming, N. Hogan, "Self-Calibrating Digital Myoprocessor," presented at 8th Annual Northeast Bioengineering Conference, Cambridge, Massachusetts, March, 1980.

L. M. Deming, "Digital Self-Calibrating Myoprocessor," SM Thesis, Dept. of Mech. Eng., MIT, June, 1980.

Neurophysiologically Based Adaptive Controllers for Assistive Devices

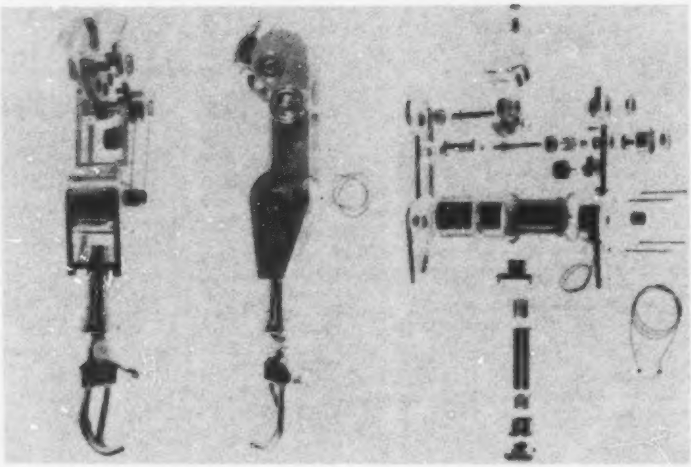
Professor N. Hogan; C. J. Abul-Haj, S. L. Cotter
Sponsors:
National Science Foundation, Fannie and John Hertz Foundation Fellowship

Because the human operator is fundamentally an adaptive controller, this project aims to give an assistive device (such as a prothesis or orthosis) the same adjustable capabilities as those inherent in the natural limb. The most important of these is the ability to tune mechanical impedance over a wide range. Available data shows that the angular stiffness about the elbow joint can be adjusted voluntarily over a range from as low as 1 Newton-meter/rad. to as high as 150 to 200 Newton-meter/rad. Angular viscosity about the joint is also tunable, though not over so wide a range.

The research methodology features a wearable, versatile, computer-controlled limb simulator. This is a laboratory device worn by an amputee which can be programmed to mimic the behavior of any proposed artificial limb design. This will permit active involvement of the potential user in the design and development. The amputee can evaluate the proposed design and indicate its weaknesses; modifications can be made directly by simply reprogramming the device.

The artificial limb simulator has been designed and built. The inherent mechanical impedance of the device is extremely low. While the performance of the simulator inevitably falls short of that of the natural arm, it amply satisfies the basic design requirement; that it be capable of mimicking the behavior of any proposed self-contained prosthesis design.

Previous analytical work revealed the importance of the mechanical coupling between non-adjacent links provided by bi-articular muscles. The focus of analytical efforts in the past year has been on the determination of the optimum functional form for the mechanical stiffness



Perspective and exploded views of the elbow prosthesis' simulator, alias "The Hogan Elbow". The elbow joint is powered by a D.C. torque motor which in turn is controlled with bioelectric activity measured from the amputees' stump.

and viscosity. Indications to date are that the optimum form is a non-linearity not unlike that of the natural limb.

Recent Publications:

N. Hogan, "Tuning Muscle Stiffness Can Simplify Control of Natural Movement," *1980 Advances in Bioengineering*, V. C. Mow, ed., ASME, New York, New York, 1980.

N. Hogan, C. J. Abul-Haj, "The Design of a Myoelectrically Controlled Upper Arm Prosthesis with Variable Mechanical Impedance," *Proceedings of the Ninth Northeast Bioengineering Conference*, W. Welkowitz, ed., Pergamon Press, New York, New York, 1981.

Determination of Mechanical Properties of Human Skeletal Joints
Professor W. P. Seering
Sponsors:
National Science Foundation, National Institutes of Health

Human joints are systems which defy simple analysis. Their geometric and kinematic characteristics are complex. Material properties of their elements are not well known or easily measured. Yet knowledge of the dynamic functioning of the joints is essential to development of an understanding of joint injuries, and to the discovery of new reconstructive methods or of synthetic tissue – replacement materials.

The work under way is directed toward measuring certain mechanical properties of the ligaments of the human knee for use in a dynamic, large-displacement, finite element model of the leg. Toward this end, many tests have been performed and a variety of parameters measured. It has been established that human ligamentous tissue is much less viscoelastic than had been previously reported. Also it has been shown that mechanical properties of ligaments change as a function of loading cycle, but that original properties return if the tissue is properly maintained for relatively short periods of time.

Recent Publications:

W. P. Seering, R. L. Piziali, D. A. Nagel, D. J. Schurman, "The Function of the Primary Ligaments of the Knee in Varus-Valgus and Axial Rotation," *Journal of Biomechanics*, **13**, No. 9, 785-794, 1980.

R. L. Piziali, W. P. Seering, D. A. Nagel, D. J. Schurman, "The Functions of the Primary Ligaments of the Knee in Anterior-Posterior and Medial-Lateral Motions," *Journal of Biomechanics*, **13**, No. 9, 777-784, 1980.

Motor Coordination: The Control of Eye, Head, and Hand Movements in Monkeys
Professors E. Bizzi (Psychology), N. Hogan, W. D. Chapple (University of Connecticut at Storrs); Dr. N. Accornero (University of Rome)
Sponsors:
National Institutes of Health, National Aeronautics and Space Administration

This project is investigating the control strategies underlying voluntary coordinated motion. A major concern is the interplay between pre-computed movement programs and sensory feedback from the distal limb segment.

Previous efforts on this project have shown that although the musculoskeletal system is richly endowed with sensory organs, feedback from these sensors is not vital for the stable execution of voluntary movement. This open-loop stability can be attributed to the inherent mechanical properties of the muscles. Because the muscles are arranged in antagonist pairs about the joints, the spring-like properties of the muscles mean that a given pair of neural activities into the agonist and antagonist muscles defines an equilibrium position of the joint segment. During a movement, neural activity can be regarded as defining a "reference trajectory" for the limb. That is, at each point in time, the neural activity defines an equivalent equilibrium position for the limb to which it would proceed were it allowed to achieve equilibrium.

Implicit in this description is the assumption that the higher command centers plan the entire movement trajectory. We tested this by using a servo-mechanism to displace the limb of a deafferented monkey executing simple pointing movements from the starting position into the target position just prior to the onset of the voluntary movement. As soon as the voluntary movement began, we released the limb. We observed that even though the agonist muscle was considerably more active than the antagonist muscle, the limb moved towards the position from which it had initially been displaced, then changed direction and returned to the position specified by the target light. This behavior is consistent with the assumption of a pre-planned trajectory.

When similar experiments were performed on intact monkeys, similar behavior was observed. This suggests that the same control strategy is used even in the presence of peripheral feedback.

Recent Publications:

E. Bizzi, N. Accornero, W. Chapple, N. Hogan, "Processes Underlying Arm Trajectory Formation," *IBRO Monograph Series, Brain Mechanisms of Perceptual Awareness and Purposeful Behavior,* C. Ajmone-Marsan, O. Pompeiana, eds., Raven Press, New York, New York, 1980.

E. Bizzi, N. Accornero, W. Chapple, N. Hogan, "Central and Peripheral Mechanisms in Motor Control," *New Perspectives in Cerebral Localization,* R. A. Thompson, J. R. Green, eds., Raven Press, New York, New York, 1980.

Evaluation and Application of Myoelectric Biofeedback
Drs. C. J. De Luca (Children's Hospital Medical Center), M.J. Rosen; A. L. Oslan, C. F. McCarthy (Children's Hospital Medical Center)
Sponsor:
National Institute of Handicapped Research - Department of Education

Partial loss of strength and control in limb muscles of people with neurological disorders or injury may be accompanied by impaired or insufficient awareness of the residual activity of these muscles. Muscle re-education therapy can enhance the amount and quality of returned function by providing patients with a signal to indicate the presence and strength of muscle contractions. Commercially-available instruments provide biofeedback of muscle electrical activity, but they are large and excessively complex (and therefore expensive) for clinical use by therapists. Accordingly, an economical, wearable device, optimized for simplicity of use by practitioners and patients has been developed, which provides an auditory cue.

The myoelectric biofeedback unit includes a pasteless electrode which requires no preparation time in securing to the skin, a substantial improvement over other available systems, which renders the device useful in busy clinical environments and at home. Its small size and light weight make it convenient for ambulatory usage. Ten units have been built and are being evaluated in the Physical Therapy Departments of six major hospitals in the Boston area. Over 700 patient applications have been documented, although it is estimated that the units have been used on well over 2,000 patients thus far. Clinicians have applied the device on a number of muscles of the upper and lower extremities for initial and program evaluation, in self exercise, and in therapy exercise (the predominant application), demonstrating its versatility. A clinical evaluation is in progress to establish the specific neuromuscular dysfunctions which benefit from biofeedback therapy in a busy clinical environment. The apparent success of the clinically tested units has led to a re-design which incorporates additional clinically-related recommendations, as well as technical improvements for facilitating manufacturing processes. A company to manufacture and distribute the device is being sought.

The Myoelectric Signal as an Indicator of Muscle Fatigue
Drs. C. J. De Luca (Children's Hospital Medical Center), R. Rosenthal (Children's Hospital Medical Center), M. Sabbahi (Liberty Mutual Research Center), R. Merletti (Politecnico di Torino, Italy); A. L. Oslan (Children's Hospital Medical Center)

Sponsor:
National Institute of Handicapped Research - Department of Education

The issue of fatigue in man is complex due to the various physiological, psychological, and metabolic phenomena which contribute to it. One category of fatigue is localized muscular fatigue which results from physiological changes in a muscle performing exhaustive contractions. Thus, a quantitative measure of localized muscular fatigue would be useful in evaluating the effectiveness of these activities. An objective measure may now be possible with the analysis of the power density spectrum of the myoelectric signal (MES) which is known to shift toward lower frequencies as a sustained contraction progresses. This shift can be accounted for by a decrease in conduction velocity of muscle fibers. Presumably, the change in conduction velocity results from a lowering of the pH of the metabolic pool of the muscle, which occurs during exhaustive contraction due to lactate accumulation.

A non-invasive device, the Muscle Fatigue Monitor (MFM), which monitors in real-time and on-line the median frequency of the MES power spectrum has been designed, constructed, and tested in our laboratory. A study was performed to monitor the median frequencies of MES signals obtained from normal subjects performing sustained constant-force isometric contractions. The median frequency consistently decreased monotonically as a function of time, a finding which is consistent with the behavior of the conduction velocity during similar fatiguing contractions reported in the literature. Furthermore, the median frequency was found to be repeatable when obtained from a given muscle of an individual.

The median frequency varied greatly among different muscles, and this variation was correlated to muscle fiber distribution. Moreover, it was higher in the female than in the male subjects for the same muscle, and in the nondominant side more than in the dominant side. No relationship was found between the initial median frequency of the MES at the beginning of the contraction and the contraction level. Changes in the intramuscular conduction velocity as caused by local ischemia, cooling, and anesthesia were associated with significant changes in the initial median frequency. Furthermore, the behavior of different muscle fiber types in response to local ischemia was detected by the changes noticed in the median frequency. It appears that changes in the median frequency may provide a reliable and meaningful indication of the muscle fiber properties in either physiological or clinical settings.

Recent Publications:

F. B. Stulen, C. J. De Luca, "Frequency Parameters of the Myoelectric Signal as a Measure of Muscle Conduction Velocity," *IEEE Trans. on Biomedical Engineering*, 28, No. 7, 515-523, 1981.

F. B. Stulen, "A Technique to Monitor Localized Muscular Fatigue Using Frequency Domain Analysis of the Myoelectric Signal," PhD Thesis, Dept. of Mech. Eng., MIT, 1980.

Dynamic Myoelectric Signal Detection and Interpretation in Gait Analysis

Professors N. Hogan, R. W. Mann; Dr. S. R. Simon (Children's Hospital Medical Center); E. A. Cunningham
Sponsor:
National Institute of Handicapped Research - Department of Education

Detection and interpretation of myoelectric signals plays a central role in clinical and experimental biomechanics. However, survey of the literature on myoelectric signal processing and interpretation in gait analysis indicates a great diversity in the approaches, wide variability in the data, and radically differing opinions as to the utility of the myoelectric signal. This project represents one aspect of an ongoing effort to understand, rationalize (and standardize) myoelectric signal aquisition processing and interpretation.

An MES transmission model was developed from basic electromagnetic theory and tissue electrical properties. The variability in conductivity and permittivity for muscle, fat, and skin tissue causes specific types of signal distortion. First, the MES undergoes a frequency-dependent refraction at the muscle/fat and fat/skin boundaries: lower frequences (≈ 100 Hz) of the MES are refracted toward vertical with respect to the boundary more than the higher frequencies (≈ 5KHz). Tissue inhomogeneity therefore introduces a measurable low-pass filter effect. Second, due to the directional arrangement of the muscle fibers, the MES is distorted: the electric field of the motor unit action potential is redirected along the fiber direction. The result is that the pickup region of each electrode is not circular, but elliptic in shape. This model of the MES tissue transmission was confirmed in experiments, and provides insights into improved electrode placement and signal analysis of dynamic MES in gait analysis.

Recent Publications:

E. A. Cunningham, N. Hogan, L. Jackson, S. R. Simon, "Effects of Tissue Layers on the Surface Myoelectric Signal," presented at the IEEE Conference on Engineering in Medicine & Biology Society, Houston, Texas, September, 1981.

E. A. Cunningham, "Effects of Tissue Layers on the Myoelectric Signal," SM Thesis, Dept. of Elec. Eng. and Comp. Sci., MIT, June, 1981.

Nonstationary Aspects of the Myoelectric Signal

Professors E. Shwedyk (Visiting), R. W. Mann
Sponsors:
Whitaker Professorship of Biomedical Engineering, University of Manitoba

During dynamic force production, the myoelectric signal may be modelled as a zero-mean, Gaussian process, the variance of which changes with time. To determine the dynamics of the variance signal a two-level force tracking experiment is performed. Repeating the experiment allows one to assemble, average, and thus estimate the variance, producing a dynamic model of the variance signal.

Based on this model, a stochastic approximation algorithm to estimate the variance signal is being developed.

Recent Publication:

E. Shwedyk, R. Subramanian, R. N. Scott, "Two Models of Force Generation," presented at the 3rd Annual Conference of the IEEE Engineering in Medicine and Biology Society, Houston, Texas, September, 1981.

Tremor Loading Studies

Dr. M. J. Rosen; Professor R. W. Mann; B. D. Adelstein, M. H. Sloan, B. E. Bates, S. R. Stapleton
Sponsors:
National Institute of Handicapped Research - Department of Education, UROP

The purpose of this project is to test the utility of mechanical loading as a noninvasive, anatomically specific, reversible means of suppressing intention tremor. If, as much of the literature suggests, altered dynamics of neuromuscular feedback loops are responsible for pathological tremor, then appropriate adjustment of the mechanical output stage of these loops should eliminate abnormal oscillation. The ultimate outcome of this work may be a wearable multi-degree-of-freedom compliant restraint system. Present experiments involve pursuit tracking in wrist extension/flexion of a visually presented random target. The subject's movements are opposed by viscous damping of rigid restraint. (In the latter case, the response variable is isometric force.) Results obtained from eight subjects with intention tremor secondary to injury and neurological disease show certain characteristics with particular clinical and theoretical significance: measures of abnormal tremor are selectively reduced by viscous loading; voluntary control over isometric force may be significantly better than position control; insensitivity of the magnitude and frequency of abnormal tremor to loading supports an autonomous oscillator hypothesis for its generation.

In a related experiment conducted with normal subjects, a mechanism has been established for the effect of inertial changes on hand tremor frequency noted in the literature. By measuring tremor in a horizontal plane, one may manipulate constant force and inertia independently, or simulate the case of postural maintenance against gravity. Results from three subjects reveal a decrease in tremor with added mass and an increase with DC muscle force.

Recent Publications:

B. D. Adelstein, M. J. Rosen, "The Effect of Mechanical Impedance on Abnormal Intention Tremor," *Proceedings, 9th Annual Northeast Bioengineering Conference*, Newark, New Jersey, March, 1981.

B. D. Adelstein, "Peripheral Mechanical Loading and the Mechanism of Abnormal Intention Tremor," SM Thesis, Dept. of Mech. Eng., MIT, 1981.

B. E. Bates, "Normal Postural Hand Tremor: Frequency and Power as a Function of Inertia and Torque," SB Thesis, Dept. of Mech. Eng., MIT, June, 1981.

M. H. Sloan, "A Damped Joystick: Evaluation and Testing Using a Two-Dimensional Tracking Task," SB Thesis, Dept. of Mech. Eng., MIT, June, 1981.

Analysis of Physiological Tremor

Professors A. Watanabe (Visiting); R. W. Mann; K. F. Hensely

Sponsors:

Whitaker Professorship of Biomedical Engineering, Japan Government Research and Study Abroad Fund, University of Tokyo

The objective of this project is the development of a new model to describe physiological tremor based on data taken during slow movement of limbs. Tremor of relatively large amplitude and mostly sinusoidal waveform is generated by relaxing antigravity muscles slowly. The advantage of this method is the elimination of mechanical oscillation of the limb segment and noise transmitted from other limb segments. Damped oscillation after a tap was also measured from which mechanical oscillation was selected using a Q factor criterion to calculate mechanical parameters.

The model is composed of a second-order mechanical component and a parallel connection of the short and long neurological feedback loops corresponding to the spinal and supraspinal reflexes. Using a least-square criterion, we determined the best fitting parameters for the data. Examples of estimated parameters for the hand are 25 ms and 71 ms for the spinal and supraspinal reflex delay times, respectively, and 0.7 for the gain ratio (long loop gain/short loop gain). The variability in tremor frequency can be explained satisfactorily as a change in the gain ratio.

The Role of Opposing Muscles for Joint Stability

Dr. C. J. De Luca (Children's Hospital Medical Center); Professor R. W. Mann; B. Mambrito, R. S. LeFever

Sponsors:

Liberty Mutual Insurance Company, Insurance Institute for Highway Safety

This project will investigate the control mechanisms of opposing muscles during initiation and continued production of force. Attempts will also be made to monitor the motor unit control properties of opposing muscles during relatively slow joint movements. The myoelectric signal of the agonist and antagonist muscles of a two-muscle joint will be detected while the muscles perform specific force patterns. The myoelectric signal will be decomposed into its constituent motor unit action potential trains by a technique previously developed in our laboratory. Statistical dependence between motor unit firing rates in the agonist and antagonist muscle will be investigated using cross-correlation techniques. The attention will be focused on two relevant physiological phenomena: co-contraction and reciprocal inhibition of agonist and antagonist muscle.

This project will yield fundamental knowledge concerning the motor control of joint movement, which is useful for the development of clinical procedures for treating weak or dysfunctional muscles.

Recent Publications:

C. J. De Luca, A. P. Xenakis, R. S. LeFever, "Evidence of Two Control Schemes for Motor Units," *The Proc. of the 10th Annual Meeting of the Soc. for Neuroscience*, 761, November, 1980.

R. S. LeFever, C. J. De Luca, "A Procedure for Decomposing the Myoelectric Signal into its Constituent Action Potentials: (I) Technique, Theory and Implementation," accepted by *IEEE Trans. on Biomedical Engineering.*

R. S. LeFever, C. J. De Luca, "A Procedure for Decomposing the Myoelectric Signal into its Constituent Action Potentials: (II) Execution and Test for Accuracy," accepted by *IEEE Trans. on Biomedical Engineering.*

R. S. LeFever, "Statistical Analysis of Concurrently Active Motor Units," PhD Thesis, Dept. of Elec. Eng. and Comp. Sci., MIT, 1980.

Development of a Compliant Orthosis for Management of Spastic Gait

Drs. M. J. Rosen, S. Simon (Children's Hospital Medical Center), M. Hallett (Brigham and Women's Hospital); Professor R. W. Mann; B. Maki

Sponsors:

National Institute of Handicapped Research - Department of Education, Canadian National Science and Engineering Research Council

The exaggerated reflexes seen in people with cerebral palsy may lead to a gait abnormality known as equinus. Individuals with this problem walk on their toes due, apparently, to uncontrollable reflex contraction of the foot plantar flexion muscles in the calf. Non-surgical intervention strategies typically involve bracing with rigid or limit-setting orthoses. While some gait improvement may be provided, a stiff-ankle gait is certainly far from normal and requires adaptive changes in gait activity of the remainder of the leg.

A project is under way to develop and test an articulated compliant ankle brace, which would suppress reflex extension of the ankle, while allowing some motion of that joint. The technique will be based on the clinical observation that the abnormal stretch reflex responsible for equinus is highly sensitive to the rate of ankle flexion. The prototype orthosis now being built will incorporate an electro-mechanical brake, which will apply resistive torques about the ankle in order to limit the angular velocity. Objective and clinical gait measurements will be made to determine its efficacy as influenced by the applied loading function.

Selective Activation of Spinal Recruitment Patterns by Afferent Electrical Stimulation

Drs. M. J. Rosen, R. W. Hussey (West Roxbury Veterans' Administration Medical Center); Professor R. W. Mann; W. K. Durfee

Sponsors:

National Institutes of Health Biomedical Research Support Grant, West Roxbury Veterans' Administration Medical Center, National Institutes of Health National Research Service Award

The clinical motivation for this project is the return of lower limb function to individuals who have lost it due to spinal cord injury. A series of canine experiments is under way to identify alternative stimulation parameters and sites for improving upon the muscle contractions evoked by the present clinical-experimental technique of whole muscle nerve stimulation. The hypothesis being tested is that it is more appropriate to evoke muscle activation through spinal reflex pathways (below the level of injury) by stimulation of afferent fibers than to stimulate efferents directly. This is based on published evidence that more physiological force levels and less fatigue may be so obtained, and that the spatial-temporal integration provided by spinal circuitry is functionally optimal.

Experimental work is presently being carried out in spinalized dogs. Isometric muscle force is measured during alternate stimulation of efferent and afferent sites. Contraction strength, fiber recruitment order, and fatigue properties are compared for the two sites. The present protocol, completed on six subjects, calls for stimulation of the anterior tibial muscle via the peroneal nerve and via the posterior tibial nerve. The latter site evokes a withdrawal reflex. Inter-subject variability has, to date, prevented firm conclusions.

Recent Publication:

W. K. Durfee, "Functional Muscle Recruitment by Electrical Stimulation of Afferent Nerves," SM Thesis, Dept. of Mech. Eng., MIT, January, 1981.

Design of a Self-Contained, Active, Regenerative Computer-Controlled Above-Knee Prosthesis

Professor W. C. Flowers; B. L. Hunter
Sponsors:
National Science Foundation, E. I. du Pont de Nemours and Company Science and Engineering Grant

Prior research, using a man-interactive powered prosthesis simulator system, demonstrated the advantages of including active functions and adaptive computer control in a prosthesis. An active prosthesis, containing a microprocessor and requiring no external power source, has been designed to provide similar benefits in an anatomically sized device. Energy required for active stance phase control is obtained by collecting and storing energy during the passive portions of the gait cycle. Computer simulations indicate that a sufficient excess of energy is collected during a typical level walking step to enable the prosthesis to be powered without batteries. Tests performed on the mechanical systems completed to date are encouraging. A regenerative, passive only, prosthesis is recommended as a logical application for the regenerative techniques used in the active prosthesis.

Recent Publications:

B. L. Hunter, W. C. Flowers, "Design of a Self-Contained, Regenerative, Active/Passive, Microcomputer-Controlled Above-Knee Prosthesis," *Proceedings of the 8th Annual Northeast Bioengineering Conference*, Cambridge, Massachusetts, March, 1980.

B. L. Hunter, "Design of a Self-Contained, Active, Regenerative Computer-Controlled Above-Knee Prosthesis," SM Thesis, Dept. of Mech. Eng., MIT, February, 1981.

Use of a New Biofeedback and Gait Analysis System in Conjunction with the Microcomputer-Controlled Above-Knee Prosthesis

Professor W. C. Flowers; Dr. J. Barr, Jr. (Massachusetts General Hospital); K. P. Tyra
Sponsors:
National Institute of Handicapped Research - Department of Education, MTS Systems Corporation Fellowship

A microcomputer-controlled above-knee prosthesis, developed at MIT, is used to evaluate an immediate post-operative training in which the versatility of the new prosthesis would provide a more gradual transition from a locked pylon to a prosthesis which has characteristics very similar to the intended permanent prosthesis.

Interaction with the first four patients who participated in the new program and with the clinical staff at Massachusetts General Hospital indicated that several additional gait training problems might be addressed by incorporating additional instrumentation into the prosthesis and microcomputer system. Weight-bearing and knee-torque transducers were added to the prosthesis, and a biofeedback and signal processing interface was built. These additions simplified recording and display of several gait parameters.

These parameters can be used in connection with the versatile prosthesis controller to provide gait training programs which more precisely address the particular patient's problems. Two patients, one young and one geriatric, have had post-operative training using the new features. In both cases, biofeedback based on weight-bearing and knee-torque proved very effective training aids. Knowing when a particular threshold was reached was reported as very beneficial by both the therapist and the patient. The knee-torque feedback was particularly useful for improving stability and confidence during stance.

Results to date indicate that electronically-controlled prostheses equipped with transducers which monitor gait parameters can substantially improve rehabilitation. The next step will be a lightweight device integrated into this system that monitors hip extension in new amputees. Designs that reduce the weight and increase portability of this system are being explored.

Recent Publications:

M. P. Shepley, W. C. Flowers, J. Barr Jr., "A Microcomputer-Controlled Above-Knee Prosthesis and Gait Analysis System," 8th Annual Northeast Bioengineering Conference, Cambridge, Massachusetts, March, 1980.

M. P. Shepley, "A Microcomputer-Controlled Above-Knee Prosthesis and Biofeedback/Gait Analysis System for Immediate Post-Operative Amputees," SM Thesis, Dept. of Mech. Eng., MIT, July, 1980.

Development of a Methodology for Design of A/K Prosthesis Controllers

Professor W. C. Flowers; J. L. Stein, B. N. Cheskin, P. K. Tan
Sponsors:
National Science Foundation, National Institute of Handicapped Research - Department of Education, E. I. du Pont de Nemours and Company Science and Engineering Grant

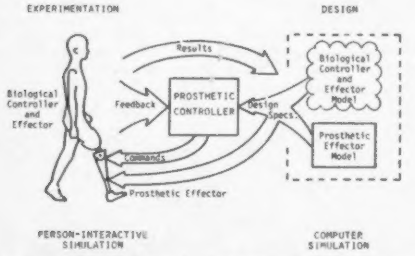
The MIT Knee Project has been, in part, exploring the research and development of leg prostheses which contain a controllable, single degree of freedom knee joint for unilateral above-knee (A/K) amputees. These prostheses can be controlled by computers and thus greatly increase the variety and sophistication of control algorithms that can be implemented. Useful exploration of enhanced prosthesis control, in turn, demands increased understanding of the human/prosthesis system.

The intent of this research project is to develop a methodology for designing control algorithms for A/K prostheses based on a quantitative study of human/prosthesis interaction. To facilitate the understanding of the human/prosthesis system, a biomechanical/mechanical model of its short-term dynamic behavior is being developed. The development is being aided by iteratively comparing the model's output to data recorded by the Laboratory's gait analysis system (TRACK) of an amputee using the MIT Knee Project's computer-controlled, man-interactive, electromechanical, active, laboratory prosthesis simulator. Differences between the biomechanical/mechanical model and the experimental data are being used to restructure the model and to fine tune the parameters of the model.

Once the validity of the biomechanical/mechanical model has been established, new controllers can be quickly and safely tested, evaluated, restructured (or fine tuned) and retested. As a result, improved A/K prostheses should be easier to design and the amputee's mobility may be increased.

Recent Publication:

J. L. Stein, W. C. Flowers, "Above-Knee Prosthetics: A Case Study of the Interdependency of Effector and Controller Design," *1980 Advances in Bioengineering, Winter Annual Meeting of the ASME*, 275-278, Chicago, Illinois, 1980.


EXPERIMENTATION
DESIGN
Results
Biological Controller and Effector Model
Biological Controller and Effector
Feedback
PROSTHETIC CONTROLLER
Design Specs.
Prosthetic Effector Model
Commands
Prosthetic Effector
PERSON-INTERACTIVE SIMULATION
COMPUTER SIMULATION

Some of the interaction pathways between the amputee, prosthetic controller and prosthetic effector that might be used to develop improved A/K prostheses.

Therapeutic Learning Devices for Handicapped Children

Professor R. W. Mann; G. F. Dalrymple, M. C. Driscoll (Kennedy Memorial Hospital), B. Ferdinand

Sponsors:

The Whitaker Foundation, The Whitaker Professorship of Biomedical Engineering, United Cerebral Palsy Research Foundation, Creative Technological Aids, Inc., UROP

Therapeutic aids for children with learning disabilities or multiple handicaps have generally been limited to those devised by the individual therapist or certain toys designed for "normal" children. Some five years ago, a UROP-sponsored program brought MIT undergraduates, predominately first year students, into the Kennedy Memorial Hospital where, with the help of Occupational Therapists, they observed the needs of multiple-handicapped children and devised possible therapeutic toys. Under the guidance of MIT faculty and staff, the students subsequently built their concepts and evaluated them in the hospital. Beyond obvious educational benefits for the MIT students, the program produced some 25 different devices enhancing training in spelling, visual sequential memory, eye-hand coordination, character recognition, tracking, motor planning, visual field improvement, tremor compensation, and number and color recognition. In order to move the more promising of these devices beyond their one-of-a-kind status, a non-profit corporation, Creative Technological Aids, Inc. (CTA) was formed to further develop and evaluate selected toys and make them available to the rehabilitation community. Magic Light Pen, an eye-hand coordination device, was selected as the initial instrument, underwent further development and evaluation, and has now been produced in small quantity by Goodwill Industries of Harrisburg, Pennsylvania. Extensive field evaluation has been very promising, leading to licensing negotiations with commercial manufacturing and marketing firms. Under the corporate charter of CTA, proceeds will finance research, development and evaluation of new toys. A second "product," Secret Code, has completed the developmental engineering and industrial design stage. A small lot for field evaluation is in manufacture.

This past term Bright Blocks, a letter recognition, eye-hand coordination toy devised some time ago, was restudied. In the original device, which has proven its therapeutic and motivational worth with the children, alphabet blocks had internal electrical matrices with exposed contacts on the cube side opposite the letter, so that only by placing the right letter in the correct orientation would a positive reinforcement occur. An optical technique was devised which eliminated any electrical circuit in the block, but which required the same placement precision to illuminate the letter.

Recent Publication:

B. Ferdinand, "Further Development of 'Bright Blocks'," UROP Final Report, MIT, January, 1981.

A Universal Communication and Environmental Control System for the Non-Verbal Motor Handicapped

Professors D. Rowell, R. W. Mann; G. F. Dalrymple

Sponsors:

United Cerebral Palsy Research Foundation, National Institute of Handicapped Research - Department of Education

The inability to speak is a very severe problem, especially when compounded with other motor handicaps. Systems which enable an impaired person to communicate with family and peers can have a significant impact on the quality of life for the user.

This project was started as a demonstration that microprocessor technology could provide the basis for electronic communicators with greatly enhanced power and with the capacity for easy adaptation to the motor abilities of individual users. The UNICOM (*Uni*versal *Com*municator) is a single, versatile piece of hardware that can be programmed to perform a wide variety of functions. The system automatically changes mode through recognizing the input device (keyboard, encoded keyboard, switch, joystick, eye movement sensor) plugged into it. A damped joystick has been adapted as an interface for a person with severe tremor and unable to operate a conventional interface. A video display is used as the primary output medium supplemented where appropriate with a hard copy printer. As an environmental control system, UNICOM provides the paralyzed person control over lamps, television, telephone, etc.

Fourteen units are in use in the field under different evaluation protocols by cerebral palsy, stroke, muscular dystrophy, and ALS victims, and by quadriplegics in both home and school environments. Another three are complete and ready for field placement. Current work is concerned with the use of the device as a computer terminal for the handicapped and as a means for allowing the handicapped to communicate amongst themselves.

Evaluation and Adaptation of Non-Vocal Communication Systems in the Clinical Environment

Dr. P. A. Drinker (Brigham and Women's Hospital); Professors R. W. Mann, D. Rowell; Dr. M. J. Rosen; G. F. Dalrymple

Sponsor:

National Institute of Handicapped Research - Department of Education

The most challenging problem confronting designers of non-vocal communication systems is the need for an overwhelming variety of interface hardware to meet the diverse needs of movement-impaired users. The most common solution to this problem is single switch control of a scanned vocabulary since simple switch closure can be adapted to virtually any physical movement. The disadvantage of scanning as a communication strategy is that it is slow and frustrating. The alternative of exploiting small amounts of residual motor control to provide several distinct control inputs for coded selection of vocabulary items is being tested in this project.

A curved harmonica-like array of pneumatic actuation tubes has been built for several regular users of the UNICOM communicator/environmental controller described above. This input device allows small "puffs" or "sips" of mouth pressure to be applied remotely to five pneumatic SPDT switches, providing ten distinct control signals. Recently, an interface that provides an auditory feedback scheme where two different audible tones are generated for the first and second commands was developed for a user who is functionally quadriplegic and has lost proprioception and sense of touch, and is nearly blind. Four quadriplegic users with radically different etiologies are presently using versions of this system daily, three at New England Sinai Hospital and one in an independent living center. Communication speeds better than 10 words/minute are common and subjective measures of acceptance are overwhelmingly positive.

EYECOM: An Eye Movement Detection Decoding System for Non-Vocal Communication

Dr. M. J. Rosen; Professor R. W. Mann; W. Durfee, P. Johnson
Sponsor:
National Institute of Handicapped Research - Department of Education

EYECOM is an opto-electronic system which allows the non-vocal quadriplegic user to communicate by means of coded sequences of gaze direction. A miniature infra-red source and a solid-state image detector are mounted on a special frame, forming a wearable gaze angle transducer. The system determines in which of nine solid angular sectors the eyes are presently fixated and how long that angle has been maintained. Eye positions held longer than an adjustable minimum time (1/3 sec. to 3 sec.) are recognized as intentional and pairs of angles followed by a straight ahead "enter" gaze are decoded and displayed as characters. While a 2-of-8 code presently provides a 64-item vocabulary, a 512-item set composed largely of whole words selected via a 3-gaze code would require only minor modification. The system presently exists in two forms, a stand-alone implementation in digital hardware, and newly-developed software for the UNICOM described above. In the latter form, the gaze transducer couples to the UNICOM through a small interface circuit, and a user- or system-initiated re-calibration routine is provided.

Clinical Engineering in Rehabilitation

Drs. P. A. Drinker (Brigham and Women's Hospital), M. J. Rosen; G. F. Dalrymple; Professors D. Rowell, R. W. Mann
Sponsor:
National Institute of Handicapped Research - Department of Education

The purpose of this project is to attempt to respond to the specific and diverse rehabilitation needs of individuals in clinical settings by application of engineering principles and technology.

Current activity includes work in many areas: developing and utilizing simple eye-movement communication boards with severely disabled non-vocal persons; testing strategies of remote communication for deaf persons working in a hospital environment; evaluating teleconferencing systems to support clinical rehabilitation engineering activity; making available a computer-based telecommunication system for use by the handicapped themselves; and practicing patient-by-patient adaptive equipment design.

During the past year, staff of the project entered collaboration as regular consultants with the newly-formed Communication Enhancement Clinic, Hearing and Speech Division, Children's Hospital Medical Center. That work includes participation in assessment of needs and functional capabilities of non-vocal children, and the design, development, and testing of switching and other control schemes for available non-vocal communication devices.

Recent Publication:

P. A. Drinker, S. Kropoff, "Eye-Link for Non-Vocal Communication: Direct Selection by Eye Contact," presented at the 4th Annual Conference on Rehabilitation Engineering, Washington, D. C., September, 1981.

Student Experiences in Rehabilitation Engineering

Professor R. W. Mann; M. C. Driscoll (Kennedy Memorial Hospital), P. L. Davock (Tri-City Mental Health Center); S. F. Idriss, M. G. Curley, C. H. Kwon
Sponsors:
Whitaker Professorship of Biomedical Engineering, UROP, Clapp and Pollak Engineering Design Award

Growing student interest in applying engineering to alleviate the limitations experienced by physically handicapped persons, coupled with the laboratory's reservoir of knowledge and capability derived from sponsored projects, catalyzes new individual efforts which do not easily fit into other ongoing projects and so are reported here.

In a Bachelor's thesis, the particular communication needs of a youth hospitalized following head trauma were satisfied under the very great restraints of his limited physical capacity, his psychological motivation and his imperative health-care requirements. In the context of solving the technical problems in this individual, the global and systems aspects of performing a rehabilitation engineering service are explored and documented.

A second Bachelor's thesis considered the hindrance to the limited capacity wheelchair traveler represented by corridor and room doors. With the goal of travel independence, the thesis proposes a design of a device attached to the wheelchair, which opens any door encountered.

In a UROP project, a sophomore is working with a 33-month-old child with a severe birth defect who is enrolled in a nursery school concerned with seriously physically handicapped children. Assistive devices to facilitate more normal function in the child are being developed and a therapeutic toy, Puff the Mighty Elephant, initially developed in the Creative Technological Aids project, is being adapted for her use.

Recent Publications:

S. F. Idriss, "A General Approach Toward Choosing Communication Systems for Seriously Handicapped

Non-Vocal Patients," SB Thesis, Dept. of Mech. Eng., MIT, May, 1981.

M.G. Curley, "Design of a Universal Door Opener for Wheelchair Restricted Persons," BS Thesis, Dept. of Mech. Eng., MIT, June, 1981.

Psychological Pacemaker for Autistic Children
Professor R. W. Mann; G. F. Dalrymple, A. Twining (Boston University), S. M. Henderson
Sponsors:
UROP, Whitaker Professorship of Biomedical Engineering

The objective of this project is to develop simple instrumentation to investigate the feasibility of substituting an external rhythm for the stereotypic behaviors which often dominate the life of profoundly disturbed (autistic) children and block their learning process.

A small, wrist mounted, solenoid driven, tactile stimulator has been described, built, and tested. Controls adjust the stimulus rate and duration with power provided by an external battery pack. Pilot data show that learning and attention span improve when this external stimulus is provided.

Braille Displays as Substitutes for Video Terminals, Instrument Output and Printed Copy
E. E. Blanco; Professor R. W. Mann; G. F. Dalrymple
Sponsors:
Whitaker Professorship of Biomedical Engineering, Ziegler Foundation, National Science Foundation

The educational, vocational, and recreational opportunities of the visually impaired are enhanced when "refreshable" Braille output can substitute for visually presented alpha-numerics. A simple and reliable solenoid-driven Braille cell developed in our laboratory has been integrated into several instruments including a digital voltmeter and has also been employed now for over two years in our Braille-adapted telephone supervisory switchboard under evaluation at Little Rock, Arkansas. The electromechanical design of this Braille cell restricts its applications to single line displays. Recently, a new design approach overcame that limitation, permitting stacking to form multiple lines as in a page display, while also incorporating latches to lock the pins, eliminating continuous expenditure of power and concomitant thermal heating. A Bachelor's thesis evaluating the concept was followed by a professional development effort which has produced a practical, manufacturable Braille cell. Conceptual designs have been prepared for a portable Braille reader with digitally stored copy on a standard magnetic tape cassette and operator control of page format presentation using a large, two-dimensional array of the new Braille cells.

Recent Publication:

F. E. Huston, "Design of a Full-Page Refreshable Reading Display," SB Thesis, Dept. of Mech. Eng., MIT, May, 1980.

A Braille Traffic Service Position System (TSPS) Console for Blind Telephone Operators
Professors D. Rowell, R. W. Mann; G. F. Dalrymple
Sponsors:
National Institute of Handicapped Research - Department of Education, Arkansas Enterprises for the Blind, Inc.

In this collaborative project with Southwestern Bell Telephone Company and Arkansas Enterprises for the Blind, Inc., a microprocessor-based refreshable Braille display of the numeric and status information on a TSPS telephone operator's console was developed and installed in Little Rock, Arkansas.

The standard TSPS console employs a complex visual display to cue the operator as to the status of the call being handled. The console has approximately 80 lamps and push-buttons, under control of a central computer, to direct the operator. It also has a 12-digit numeric display unit to display telephone numbers, charges, etc. The adaptation of the system for the blind posed some unusual problems, including the condensing of the display into 12 Braille cells, and allowing the operator to take notes for later manual billing.

Two systems have been installed and have been in use since 1977. Two blind operators have been trained and are fully employed. The project has been judged as highly successful by all concerned. During 1978 the technology was transferred to a commercial company for the development of a production design that uses Braille and synthetic speech output. Prototypes of the new system are now being field tested at a Pacific Bell installation. An estimated three hundred switchboard operator jobs nationwide will be created for blind and severely visually impaired persons.

Enhancement of Mobility for the Blind
Professors D. Rowell, R. W. Mann; Dr. S. Tachi (Visiting); J. Serocki, G. Yamaguchi
Sponsors:
National Institutes of Health, Japanese Government Research and Study Abroad Fund

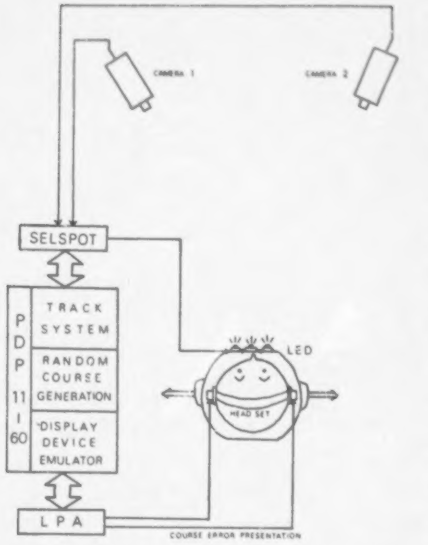
Electronic mobility aids for the blind must extract information from the environment and display this information in a non-visual form. This project seeks to elucidate new methods of abstracting spatial information from the environment and displaying that information through a non-visual sense in order to improve the orientation and mobility of the blind. In particular, the behavioral characteristics of the auditory and tactile senses, under experimental conditions that allow dynamic exploration of the environment, are being studied in order to specify new forms of electronic travel aids for the blind.

An objective of this project is to study the assimilation of information under conditions of free volitional movement in the environment. To this end, the infra-red TRACK position monitoring system is being extended to allow remote monitoring of human movement within a large volume. A computer-based display simulator is being designed so as to allow the monitoring of the position of a subject and the generation of new display codes in real time. For evaluation of auditory codes, high-fidelity earphones suffice as the psychophysical interface with the mobile human. For tactile communication, two-dimensional arrays of electrocutaneous stimulators are being designed and fabricated which, for example, can provide range and azimuth information to obstacles in the path of the traveller.

Recent Publications:

J. H. Serocki, "Development and Evaluation of an Electrocutaneous Dynamic Phantom Sensation," SM Thesis, Dept. of Mech. Eng., MIT, May, 1981.

G. T. Yamaguchi, "Digital Synthesis of Auditory Localization Information," SM Thesis, Dept. of Mech. Eng., MIT, May, 1981.



Real-time study of auditory surrogates for vision for blind mobility using the TRACK system.

Optimizing Long Cane Techniques for Blind Travellers

Professor R. W. Mann; M. M. Uslan (American Foundation for the Blind), K.Schriebman
Sponsor:
UROP

The long cane is widely used by peripatetic blind persons to ascertain whether the next step is safe and to explore for orientation cues. The cane scanning techniques employed and the choices of coordination of arm and leg movement have developed experimentally with essentially no benefit of rigorous analysis. This study is developing mathematical expressions for the relationships between the geometry of the body and gait parameters and cane length in order to perform optimization studies. For example, which of the various coordination strategies best ensures full path coverage? Or how does one tradeoff between cane length and confidence that the traveller does not overstep the cane's forward coverage? Trajectories defined by the analyses will be compared with traveller experiments using TRACK kinematic data acquisition in the Mobility Laboratory.

Recent Publication:

M. M. Uslan, K. Schriebman, "Drop-Off Detection in the Touch Technique," *Journal of Visual Impairment and Blindness*, May, 1980.

Ultrasonic Computerized Travel Aid for Blind Persons

Professor R. W. Mann; Dr. C. H. Biber (Polaroid Corporation); M. M. Uslan (American Foundation for the Blind), W. R. Smith (Boston College), K. Schreibman
Sponsors:
UROP, Eloranta Summer Fellowship, American Foundation for the Blind, Polaroid Corporation, National Institute of Handicapped Research - Department of Education

The American Foundation for the Blind is developing a Computerized Travel Aid (CTA) based on the ultrasonic ranging system used in the Polaroid Instant Cameras. Engineering specifications for the ultrasonic beam width and range are being developed in conjunction with the Sensory Institute at Boston College, which educates orientation and mobility instructors for the blind. The desirability of achieving both a broad beam with side lobes of shorter range and a pencil beam of extended range has been established, as well as the ability to switch from beam to beam.

This research is addressing the means of achieving the desired beam modifications.

BLINDSIGHT — An Informational Film on Mobility Techniques Employed by Blind Persons

Professors R. W. Mann, R. Leacock (Arch.); M. C. Starkey
Sponsors:
Perkins School for the Blind, Whitaker Professorship of Biomedical Engineering

BLINDSIGHT is a 22-minute, 16 mm, sound, color movie focused on a specific, informed audience, in contrast to more general science communication films aimed at audiences with little formal knowledge of a topic. It strives to combine the documentary-like style of information communication with the personal experience, emotional involvement style of cinema verité.

Through the comments and performances of blind persons and their orientation and mobility instructors, the film introduces the psychological and practical aspects of location knowledge, movement, and navigation without vision, and describes training, travel with the long cane and the guide dog, and augmentation of traditional mobility aids with ultrasonic and laser devices. The film concludes with a discussion of contemporary research in the mobility of the blind, particularly the search for optimal sensory substitution surrogates for the lost visual sense. Studies of auditory and tactual presentation of spatial information in a human-interactive computer simulated travel space concludes the film.

The film will be circulated to interested viewers as part of a film library on blindness and deaf-blindness offered by the Perkins School for the Blind.

Recent Publication:

M. C. Starkey, "BLINDSIGHT," SM Thesis in Science Communication, MIT, June, 1981.

Development of a Short Course for Practitioners on Construction of Practical Rehabilitation Devices

Drs. M. J. Rosen, P. A. Drinker (Brigham and Women's Hospital); D. Wallace (Kennedy Memorial Hospital); G. F. Dalrymple, M. Sloan, F. Barg
Sponsor:
UROP

Rehabilitation practitioners such as occupational therapists, physical therapists, and special education teachers are often in a position to identify, at least conceptually, the need for therapeutic and assistive devices for their clients. Insufficient information, technical services, or funds frequently prevent these needs from being met. Work has begun on the development of a practical short-course/workshop which would provide non-technical individuals with the competence, confidence, knowledge of resources, and instructional notes necessary for construction of several specific devices as they are needed by disabled clients. This project is simultaneously a novel design exercise and an experiment in inter-professional education. Designs for rehabilitative devices will necessarily be optimized for economy and availability of components, electrical safety, simplicity of assembly, and minimal tool requirements. The instructional "cookbook" must be free of specialized vocabulary and be pictorial, rather than schematic.

Recommendations from practitioners on device needs have been solicited through local and national contacts. The design and construction of a simple "clockface" non-vocal communication device has been completed as a UROP project to test a variety of low technology hardware which may be applicable to do-it-yourself construction of other devices. An actuator switch with independently-variable force and throw has also been built and is in use at Kennedy Memorial Hospital as part of a biofeedback training device.

Pathogenesis of Osteoarthritis – *In Vitro* Studies

Professor R. W. Mann; Dr. W. H. Harris (Massachusetts General Hospital); R. G. Burgess; S. Tepic, T. Macirowski, H. Brun

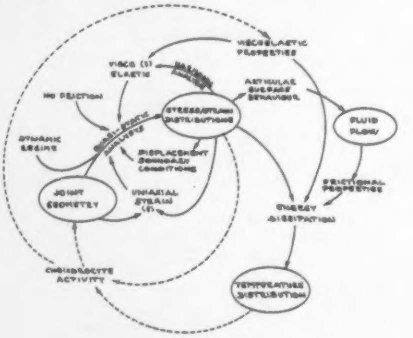
Sponsors:

National Institutes of Health, Whitaker Professorship of Biomedical Engineering, UROP

Osteoarthritis, or degenerative arthritis, disables more Americans than any other disease, producing much pain and loss of mobility while causing the greatest loss in worker productivity. This project is exploring in detail how the human hip joint accommodates the forces and displacements of normal movement and whether, and if so how, these mechanical factors contribute to the pathogenesis of osteoarthritis. The *in vitro* phase of the investigation is developing, through analysis and experiment on human hips from cadavers, a detailed model of the cartilage and bone in this ball-and-socket synovial joint. Our testing facility consists of a unique electro-hydraulic hip simulator interfaced with a PDP 11/40 minicomputer for programmed experimental control and data acquisition and analysis. A novel ultrasonic gauging system deployed in the hip simulator produces precise and detailed maps of the surface contours of cartilage and underlying bone and of cartilage thickness distribution on both acetabulum and femoral head. Both unloaded cartilage surfaces are essentially spherical, with small local deviations, but the underlying bone is quite irregular. The ultrasonic reflections also provide detailed quantitative information on the mechanical properties of the cartilage.

A UROP project using cores excised from the cartilage and bone is correlating the ultrasonic thickness measurement with direct optical determination.

Instrumented pseudo femoral head prostheses measure the detailed time-dependent surface pressure distribution, friction forces, and penetration into the human acetabulum under load. Acetabuli deemed normal demonstrate very irregular pressure distributions which we have shown correlate with localized percentage compression of cartilage derived from our independent geometric measurements, with the highest local pressures due primarily to local asphericities at the cartilage-calcified cartilage interface. We have found cartilage is subject to much higher pressures than heretofore suspected and pressure gradients with distance along the cartilage surface are quite severe. The consequences of these high stresses and gradients on the mechanical response of the collagen/proteoglycan matrix of cartilage and on the chrondocyte cells which nurture and repair cartilage are under investigation.



Interrelationship of mechanical factors and biology in load carriage of articulating synovial joints.

Recent Publications:

S. Tepic, R. W. Mann, W. H. Harris, "Ultrasonic Measurement of the Femoral Head Geometry," presented at the 26th Annual Orthopaedic Research Society, Atlanta, Georgia, February, 1980.

P. D. Rushfeldt, R. W. Mann, W. H. Harris, "Improved Techniques for Measuring *in vitro* the Geometry and Pressure Distribution in the Human Acetabulum," Part I: "Ultrasonic Measurement of Acetabular Surfaces, Sphericity and Cartilage Thickness," *J. of Biomechanics*, **14**, No. 4, 253-260, 1981.

P. D. Rushfeldt, R. W. Mann, W. H. Harris, "Improved Techniques for Measuring *in vitro* the Geometry and Pressure Distribution in the Human Acetabulum," Part II: "Instrumented Endoprosthesis Measurement of Articular Surface Pressure Distribution," *J. of Biomechanics*, **14**, No. 5, 315-323, 1981.

S. Tepic, R. W. Mann, W. H. Harris, "Geometry of the Human Hip Joint," *Proceedings of the 8th Annual Bioengineering Conference*, Cambridge, Massachusetts, March, 1980.

R. W. Mann, P. D. Rushfeldt, W. H. Harris, "Quantitative Synovial Joint Geometry and Load Distribution," 4th Annual Conference of the American Society of Biomechanics, Burlington, Vermont, October, 1980.

R. W. Mann, S. Tepic, P. D. Rushfeldt, W. H. Harris, "Quantitative Synovial Joint Geometry, Congruency and Local Distribution," *1980 Advances in Bioengineering*, ASME, New York, New York, December, 1980.

S. Tepic, R. W. Mann, W. H. Harris, "Analytical Approach to Interarticular Congruency of the Human Hip Joint," presented at the 27th Annual Orthopaedic Research Society, Las Vegas, Nevada, February, 1981.

R. W. Mann, P. D. Rushfeldt, S. Tepic, T. Macirowski, W. H. Harris, 'Synovial Joint Mechanics via a Model Incorporating Precise, Global Cartilage Thickness Distributions," presented at the VIIIth International Congress on Biomechanics, Nagoya, Japan, July, 1981.

T. Macirowski, S. Tepic, R. W. Mann, W. H. Harris, "Topographical Variation of the Impedance of the Cartilage Layers in the Human Hip Joint," to be presented at the 28th Annual ORS, New Orleans, Louisiana, January, 1982.

Dynamics of and Entropy Production in the Cartilage Layers of the Synovial Joint

Professors R. W. Mann, M. P. Cleary, B. B. Mikić, H. M. Paynter; Dr. W. H. Harris (Massachusetts General Hospital); S. Tepic
Sponsors:
National Institutes of Health Biomedical Research Support Grant, Whitaker Professorship of Biomedical Engineering

The ultrasonic data describing the global and local cartilage layer geometry is discrete, with 400 locations for the femoral head and 300 for the acetabulum. In order to manipulate the experimental cartilage geometric data analytically, spherical harmonic series up to the 19th degree have been fitted to the discrete data points to generate continuous, smooth functions which approximate both surfaces of the two mating components within experimental error. These expansions are then employed in simulated articulations of the head and socket under load and motion to establish the congruency of opposing cartilage surfaces at initial contact for different joint articulation angles. Preliminary results suggest that the "congruency" index of interarticular fit is poorest at heel strike during gait, a time of high impulsive loading, and best at hip angle corresponding to sitting posture.

The dynamic response of cartilage to load *in situ* will be analyzed, assuming appropriate constitutive properties for cartilage. The resulting shape of the loaded interarticulating surface will elucidate global joint bearing action and indicate the appropriate shape for rigid endoprostheses. Quantification of stress and strain in and on cartilage, and of entropy production in cartilage will address the respective roles of mechanical and thermal factors in cartilage deterioration.

Recent Publications:

S. Tepic, R. W. Mann, W. H. Harris, "Analytical Macrogeometry Representation and Congruency of the Human Hip Joint," presented at the 4th Annual Conference of the American Society of Biomechanics, Burlington, Vermont, October, 1980.

S. Tepic, T. Macirowski, R.W. Mann, W. H. Harris, "Entropy Production in the Cartilage Layers of the Human Hip Joint," to be presented at the *28th Annual ORS*, New Orleans, Louisiana, January, 1982.

S. Tepic, T. Macirowski, R. W. Mann, W. H. Harris, "Behavior of Cartilage Layers Subjected to Periodic Dynamic Regimes," to be presented at the 5th Annual Conference of the American Society of Biomechanics, Cleveland, Ohio, October, 1981.

Local Stress Concentrations in the Pathogenesis of Osteoarthritis

Professor R. W. Mann; Dr. W. H. Harris (Massachusetts General Hospital); T. Macirowski
Sponsors:
The Kroc Foundation, Whitaker Professorship of Biomedical Engineering

Mechanical factors, the pressure induced in cartilage under load-bearing combined with the detailed geometry of cartilage, must figure in tissue deformation and fluid flow essential to normal bearing action of synovial joints. Using a modified Moore prosthesis, the local pressures in intact human hips under physiological loads are directly measured *in vitro*. An ultrasonic technique is used to provide detailed maps of the geometry of the unloaded cartilage surface, calcified interface, and cartilage thickness. Under load, the compression of the cartilage has been found to be intimately related to the surrounding geometry, especially the irregular shape of the underlying cartilage-calcified cartilage interface.

This work seeks to assess the possible role of the irregular local geometry in causing stress concentrations in the cartilage, leading to fatigue failure of the collagen fibers in the superficial zone. By systematically examining the pressure-geometry interrelationship under various loading conditions, and relating the stresses experienced by the cartilage in its normal geometry to traditional methods for testing mechanical properties, the possible role of mechanical failure in osteoarthritis will be explicated.

Recent Publications:

T. Macirowski, R. W. Mann, W. H. Harris, "The Influence of Load Parameters on Pressure Distributions in the Human Hip Joint," *Proceedings of the 8th Annual Northeast Bioengineering Conference*, Cambridge, Massachusetts, March, 1980.

T. Macirowski, R.W. Mann, W. H. Harris, "Local Variations in the Pressures in the Human Hip Joint," presented at the 4th Annual Conference of the American Society of Biomechanics, Burlington, Vermont, October, 1980.

Pathogenesis of Osteoarthritis – *In Vivo* Studies

Professor R. W. Mann; Drs. W. H. Harris (Massachusetts General Hospital), F. J. Halcomb, III; R. G. Burgess, S. Tepic, E. K. Antonsson, T. J. Macirowski
Sponsors:
National Institutes of Health, Whitaker Professorship of Biomedical Engineering, Sloan Fund for Basic Research

Verification of the magnitude and direction of applied loads in the *in vitro* studies (described above) will be obtained from an instrumented prosthesis to be implanted in consenting patients who present for reconstruction of the hip joint following traumatic or disease loss of the femoral head. Externally and physiologically, the instrumented prosthesis is identical to the standard endoprosthesis. Fourteen load-sensing diaphrams on the load bearing surface, identical to those in the *in vitro* apparatus, telemeter dynamic pressure fluctuations providing data to establish the pressure distributions and overall load vector.

In anticipation of the first permanent implant we have conducted acute procedures in which the surgeon employs early versions of the *in vitro* prosthesis to increase the confidence level of correct sizing of the permanently implanted standard prosthesis. A force-sensing holder permits the surgeon to enter each of a progressively sized set of instrumented prostheses into the exposed acetabulum. A qualitative and quantitative display (in the operating room) indicates the distribution and magnitude of pressure for each size. Thus, the surgeon can select for permanent implantation the size of endoprosthesis which maximizes congruency. Concurrently, data is stored in the PDP 11/03 computer in the operating room for future plotting and analysis in the PDP 11/40 in our MIT Laboratory.

Recent Publications:

R. W. Mann, "Measurement of Pressure Distribution in the Human Hip Joint," 4th Society for Experimental Stress Analysis International Congress on Experimental Mechanics, Boston, Massachusetts, May, 1980.

F. J. Halcomb, III, "Pressure Distribution on the Human Hip Joint *in Vivo* and Selection of Hemiarthroplasty," SM Thesis, Dept. of Mech. Eng., MIT, August, 1980.

Compliance of the Human Acetabulum

Professor R. W. Mann; Dr. W. H. Harris (Massachusetts General Hospital); T. P. Harrigan
Sponsors:
Whitaker Health Sciences Fund, Whitaker Professorship of Biomedical Engineering

The bony socket of the acetabulum, in which the hip joint is located, is part of the human pelvis. This complex structural element is subject to multiple forces and resulting deformations. The spinal column at the center of the pelvis supports the upper body while the femur transmits foot-ground reactions and other inertial forces. The vector of the femoral head force against cartilage generates a pressure distribution which distorts the socket. Multiple, massive muscles connect the pelvis to adjoining bones exerting distributed forces.

This project is studying the strain distribution in cadaverous pelvi under simulated physiological loading conditions. A novel technique has been devised for simulating the distributed connection of the abductor muscle to the pelvis using a matrix of piano wires musically tuned to insure equal tension in each. Experimental strain data will be correlated with analyses of a finite element model of the pelvis. The trabecular structure of the bone in the pelvis is more complex than in long bones which have been modelled as isotropic. Experiments have established the three elastic moduli of trabecular bone as functions of a measureable variable, bone density.

Recent Publications:

T. P. Harrigan, I. Oh, W. H. Harris, R. W. Mann, D. R. Carter, "The Anisotropic Properties of Trabecular Bone," *Proceedings, 8th Annual Northeast Bioengineering Conference*, Cambridge, Massachusetts, March, 1980.

T. P. Harrigan, D. R. Carter, R. W. Mann, W. H. Harris, "The Influence of Apparent Density and Trabecular Orientation on the Elastic Modulus of Cancellous Bone," trans. of the 27th Annual Orthopaedic Research Society, Las Vegas, Nevada, February, 1981.

Pathogenesis of Osteoarthritis – Biological Correlates of Mechanical Factors

Professor R. W. Mann; Dr. W. H. Harris (Massachusetts General Hospital); S. Tepic, T. J. Macirowski, B. Louwerenburg
Sponsors:
Whitaker Professorship of Biomedical Engineering, National Institutes of Health Biomedical Research Support Grant

Mechanical factors are increasingly implicated in the induction of degenerative arthritis in synovial joints, either alone, perhaps by defibrillating the collagen matrix, or in combination with biochemical and cellular events. Cartilage is avascular. Therefore, all nutrients to the cartilage sustaining cells, the chrondocytes, must arrive by diffusion through the synovial fluid. The metabolic response of such cells to pressure has been determined by their proteoglycan synthesis using radio-isotope take-up techniques in the Orthopaedic Research Laboratory at Massachusetts General Hospital. Recent experiments using segments of calf carpal joints have produced consistent relationships between metabolic activity and pressure.

In order to correlate the histology, biochemistry and metabolic activity of *in situ* cartilage with mechanical factors, a coring technique has been developed. Following the generation of detailed geometric and pressure information *in vitro* in the hip simulator, a special coring tool extracts small-diameter samples of cartilage and bone at regions of especial interest which are evaluated biologically and compared to the mechanical data.

Approximately 20 cores were resected from each of two acetabula. The DNA, glucosamine, galactosamine, and uronic acid contents of each core were determined biochemically and the resulting spatial distributions compared with the global pressure distributions. The data suggests that regions of high local static pressure exhibit higher local DNA concentration (a measure of chrondocyte cell population) and lower concentrations of the other constituents. These results would imply local deterioration of the cartilage matrix.

Recent Publications:

C. F. Kaye, L. Lippiello, H. Mankin, T. Numata, "Evidence for a Pressure Sensitive Stimulus Receptor System in Articular Cartilage," presented at the 26th Annual Orthopaedic Research Society, Atlanta, Georgia, February, 1980.

B. Louwerenburg, "A Study of Human Acetabular Cartilage: Static Load Pressure Distribution Influence on the Concentration of Several Matrix Components," SB Thesis, Dept. of Mech. Eng., MIT, June, 1981.

Monitoring of Strain in an *In-Vivo* Spinal Prosthesis

Professors D. Rowell, R. W. Mann; Dr. J. E. Hall (Children's Hospital Medical Center); R. Reilly
Sponsor:
National Institute of Handicapped Research - Department of Education

Scoliosis is a disabling lateral curvature of the spine occurring most frequently in adolescent girls. A relatively new surgical procedure to correct scoliosis involves attaching a flexible cable, via an anterior approach, to the convex side of the spine to immobilize it during spinal fusion. This project is directed towards developing data to interpret how tension in this cable varies during the post-operative recovery period. A miniature implantable telemetry unit has been designed to be attached to the cable at the time of surgery. When interrogated by a non-invasive device, the implant transmits the strain in the wire. A series of prototype units were implanted in six dogs for more than one year, and have demonstrated stable operation and no adverse tissue reaction. For human implantation, the electronic and mechanical designs are under revision. The strain-detecting element and the mechanical packaging are being redesigned. A custom electronic integrated circuit to conserve energy and volume has been designed, fabricated, and tested *in vitro*.

Recent Publication:

R. Reilly, "An Implantable Biotelemetry System for the Dwyer Scoliosis Instrumentation," SM Thesis, Dept. of Mech. Eng., MIT, June, 1981.

Non-Invasive Measurement of Intracranial Pressure in Infants
Professor R. W. Mann; Dr. E. S. Conner (Children's Hospital Medical Center); J. M. Berkow
Sponsors:
UROP, Clapp and Poliak Engineering Design Award

Intracranial pressure is an important parameter which increases in a number of pathological conditions. Frequent determination of the pressure is necessary in order to treat neurological conditions such as hydrocephalus, head trauma, and encephalopathy.

In the adult, all current methods of measuring intracranial pressure are invasive in the sense that they require operative placement of a transducer beneath the skull. This is necessary, of course, because the adult brain is enclosed entirely by the skull. On the other hand, the skull of a newborn infant is incompletely closed at the fontanelle. This is an area where bone has not yet been formed and acts as a membrane which readily bulges when the intracranial pressure is elevated. It should therefore be possible to measure the intracranial pressure non-invasively by determining the tautness of the fontanelle, thus making a puncturing of the central nervous system unnecessary. In addition to avoiding the complications of infection, hemorrhage, or local damage which may result from needle puncture, any such method would allow the repeated or continuous estimation of intracranial pressure.

Several methods for continuously measuring intracranial pressure non-invasively have been devised, but is it unlikely that they will become common in practice. They are either two expensive, too impractical, or they simply do not work. The method practiced by most physicians today is simply to place two fingers on the fontanelle and estimate the pressure within.

This UROP project includes the design, construction, and clinical testing of a device for quantitatively measuring the intracranial pressure in an infant, making use of the anterior fontanelle.

Normal Pressure Hydrocephalus
Professor R. W. Mann; C. A. Hakim
Sponsors:
Whitaker Professorship of Biomedical Engineering, National Institute of Handicapped Research - Department of Education, Cordis Corporation

Hydrocephalus is a pathological condition where an imbalance exists between the rate of formation and absorption of cerebral spinal fluid (CSF) sufficient to yield a net accumulation of fluid within the cerebral ventricles. The ventricles enlarge, compressing brain tissue and blood supply within the rigid cranial cavity of the adult or expanding the soft immature bony skull of the infant.

In ordinary hydrocephalus the CSF pressure in the ventricles is elevated and shunt valves are routinely surgically implanted to vent excess fluid into the right atrium of the heart or the peritoneal cavity. In Normal Pressure Hydrocephalus an initial dilation of the ventricles due to increased CSF pressure is followed by a drop of pressure to the normal value, but leaving the ventricles dilated with concomitant sustained injury to brain tissue. The simple, over-pressure shunting techniques are not effective. This study is directed towards a surgically implantable CSF fluid control system which will first return the ventricles to their proper size and then hold them at that volume.

APPENDIX

Additional Material Submitted for the Record

Congressional Research Service
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Washington, D.C. 20540

LETTER OF SUBMITTAL

June 8, 1982

Honorable Doug Walgren
Chairman, Subcommittee on
Science, Research, and Technology
Committee on Science and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

We are pleased to transmit a summary of the hearings, held by the Subcommittee on Science, Research, and Technology, on the National Science Foundation's fiscal year 1983 budget. The hearings were held on February 23 and 25, and March 4, 1982. The summary material was prepared at the request of Paul Maxwell of the subcommittee staff. Genevieve J. Knezo, Specialist in Science and Technology, of the Science Policy Research Division, prepared the summary using the unedited transcript of the hearings. The material was reviewed by William Boesman, Specialist, and Gail H. Marcus, Assistant Chief, of the Science Policy Research Division.

We hope that the material will be helpful to the subcommittee in its work.

Sincerely,

Gilbert Gude

Gilbert Gude
Director

I. INTRODUCTION AND SUMMARY

A. INTRODUCTION

The Subcommittee on Science, Research, and Technology, chaired by Representative Doug Walgren, held three days of hearings on the National Science Foundation's authorization request for the fiscal year 1983 on February 23, 25, and March 4, 1982. This summary of the hearings is based on the unedited transcript.

The first day of hearings was devoted to the issues of international science and technology, intergovernmental science, and the behavioral and social sciences. The second day of hearings focused on issues of science and engineering education. The topics for the third day of hearings were programs for minorities and women, programs for the handicapped, and research instrumentation.

The National Science Foundation witnesses were Dr. John B. Slaughter, director, National Science Foundation, Dr. Donald N. Langenberg, deputy director, National Science Foundation, Dr. Lewis Branscomb, chairman of the National Science Board, and Dr. Ernestine Friedl, a member of the National Science Board.

B. SUMMARY OF THE NSF BUDGET FOR THE FISCAL YEAR 1983

NSF director John Slaughter gave a summary of the NSF budget request for the fiscal year 1983, which he said was increased $85 million over that of fiscal year 1982, to $1.055 million. This figure constituted an increase of 8.7 percent in current dollars. However, it included transfers from other agencies ($13.4 million from the U.S. Coast Guard to support icebreakers for the U.S. Antarctic Program, and $1.33 million from the Department of Education to support the

Minority Institutions Science Improvement Program). Without the tranfers, the actual fiscal year 1983 budget increase over fiscal year 1982, not corrected for inflation, was about seven percent.

Dr. Slaughter emphasized that the NSF budget request was "shaped within the overall context of the President's economic recovery program," and that the budget was formulated with the objective of linking support for science and technology and the achievement of economic goals. He said that ". . . all program activities and priorities provide the very largest possible return on the dollars invested in research to support the Nation's needs for future scientific and engineering knowledge." The program priorities and funding levels, he said, were balanced in terms of meeting four priorities established to generate a maximum return on investment. The four priorities were: excellence, support for a broad base of disciplines, support for national needs, and support for a few high-leverage opportunities.

C. PRIORITY SUPPORT REQUESTED FOR SOME DISCIPLINES

The Administration chose to emphasize support for only some disciplines in the NSF research budget, Dr. Slaughter testified, because: "We believe that these areas represent the greatest opportunities for scientific advancement and for making long-term contributions to the nation's economic and defense goals." The disciplines were the physical sciences, the earth sciences, and engineering. Within these disciplines, the support of fundamental research received priority. Funding requested for these disciplines for the fiscal year 1983 was increased over the fiscal year 1982 levels as follows (in current dollars):

- physical sciences, the support requested for mathematical and physical sciences was increased 9.5 percent over the fiscal year 1982, including a 14 percent increase for computer sciences;

- earth sciences, up 17.8 percent over the 1982 figure, with particular emphasis given to oceans research dealing with the continental regions; and
- engineering, the budget request was 9.8 percent larger than the 1982 current plan, with the emphasis given to "mechanical engineering and applied mechanics, . . . electrical, computer, and systems engineering." Within these priority areas, the topics of robotics and fluidics would be emphasized.

Another support area emphasized in the fiscal year 1983 budget request was instrumentation in university laboratories, which Dr. Slaughter said had been increased 12.7 percent over the fiscal year 1982 budget, to $94.2 million.

Funding for behavioral and social science research would not be increased significantly in the fiscal year 1983, according to the director, since late in 1981 the Administration increased funding for these areas in NSF by 53 percent over what it had originally requested for the fiscal year 1982. 1/ The increase made in the fiscal year 1982 operating plan represented a response to the criticism that had been levied against the NSF for the reduction it originally advocated for these areas, constituting 70 percent over the fiscal year 1980 plan. Also, in part, the increase represented the Foundation's response to a statement of the National Science Board that accorded the behavioral and social sciences status equal to other areas of science.

In the Scientific, Technological, and International Affairs Directorate (STIA), special attention in the fiscal year 1983 would go to the following areas: the program of industrial science and technological innovation, including the topics of industry-university cooperative projects, industry-university

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1/ U.S. Congress. House. Committee on Science and Technology. Authorizing Appropriations to the National Science Foundation. Report [to accompany H.R. 5842]. Apr. 26, 1982. 97th Cong., 2d Sess. House report no. 97-485. Washington, U.S. Govt. Print. Off., 1982, p. 8.

cooperative centers, and small business research; and international programs, whose funding levels were planned to be increased 9.1 percent, primarily for the support of bilateral agreements with Western Europe and Latin America. According to Dr. Slaughter, the intergovernmental program (which ". . .aided in the transfer of technology from Federal programs to State and local governments)," had been supported in the STIA directorate. However, the Foundation requested only $500,000 in the fiscal year 1983 budget request for intergovernmental programs, a decrease of $5 million since 1981. Dr. Slaughter cited "federalism" in part as justification for the cutbacks. He said that the Foundation determined that ". . . we would encourage the transfer of the funding responsibility of those programs from the Federal Government to more support from local governments and from industry and that our responsibilities should be more one of coordinating and providing an information transfer service."

The director also testified that funding for science and engineering education would be cut from $20.9 million to $15 million, and that the NSF Science Education Directorate would be eliminated. The only remaining science education support activity, per se, was a $15 million program for graduate fellowships.

In their opening statements several members, including Subcommittee Chairman Doug Walgren and former Chairman Congressman George Brown, seemed pleased with the overall budget. According to Mr. Walgren: "I think we all agree that the overall budget being requested appears to be fairly reasonable." Generally, members agreed that the NSF budget "fared better in 1983 than in 1982 and that research support functions did especially well." Major objections were heard, however, about the cuts in the science education program.

II. SCIENCE AND ENGINEERING EDUCATION

One day of hearings was devoted to the issue of science and engineering education, which proved to be a major focus of the committee's attention. In addition to the director and deputy director of the National Science Foundation, witnesses were:

Dr. Lewis Branscomb, chairman of the National Science Board;

Dr. James Rutherford, American Association for the Advancement of Science;

Mr. Robert Finnell, executive director, Mathematics, Engineering and Science Achievement Program (MESA), University of California, Berkeley;

Ms. Nancy Kreinberg, director, Math and Science Education for Women, Lawrence Hall of Science, Berkeley;

Dr. Thomas Wenzlau, president, Ohio-Wesleyan University;

Ms. Sarah E. Klein, president, National Science Teachers Association;

Dr. Robert Glaser, University of Pittsburgh; and

Dr. Saul Fenster, president, New Jersey Institute of Technology.

A. INTRODUCTION

Impetus for devoting a full hearing session to science education was motivated by the cuts in the National Science Foundation budget request for science education for the fiscal year 1983, the latest in a series of massive cuts over the last few years. In the fiscal year 1980, science education was funded at the level of about $80 million. This was decreased to $71 million in the fiscal year 1981. In the fiscal year 1982, the House approved an authorization level of $35 million and an original appropriations level of $27.7 million. However, budget constraints reduced the final appropriation to $20.9 million (P.L. 97-101). Fifteen million dollars of the fiscal year 1982 appropriation went to support graduate fellowships. The rest was to be allocated to support prior program commitments and the National Science Board-created Commission on Precollege Education in Mathematics, Science, and Technology.

The fiscal year 1983 budget request for science and engineering education was for $15 million to be allocated only to graduate fellowships. Part of that total was to be obligated exclusively for support of minority graduate students. All other precollege, undergraduate, curriculum development, and teacher training programs were to be terminated. NSF officials stressed however, that more than $15 million effectively will be available for education. According to Dr. Slaughter:

> . . . There is a significant education component in our overall program. Our primary responsibility is scientific research and education, and we are maintaining our support for some 9,000 graduate students who will be supported by our research grants, in addition to the 500 new students who will be supported by graduate fellowships, 1,500 approximately overall.

B. OVERVIEW OF CRITICISMS EXPRESSED BY SUBCOMMITTEE CHAIRMAN

Subcommittee Chairman Walgren opened the hearing session with a statement that reflected the concerns expressed by most of the members. Last year, he said, the committee in its authorization report recommended against terminating the Science Education Directorate and sought ". . . a substantial increase in funding for . . . [it]. . . . Though the final numbers were reduced, it was very clear the sense of Congress was that these programs be continued, and hopefully strengthened in the next budget." The current budget, he said ". . . seems . . . to be going in the wrong direction. It proposed reducing the science and engineering education programs a further 30 percent and eliminating all but the graduate fellowship program." Also he criticized the NSF director's plan to dismantle the Science and Engineering Directorate and to replace it with a Commission on Precollege Education in Mathematics, Science, and Technology, which, he said, "presumably . . . will come forward at some point in the distant future and make its recommendations. We will then be forced to rebuild once again."

In his opening statement the subcommittee Chairman said that

> . . . the education activities of the NSF are now reduced over 81 percent since 1981 and they would be reduced 30 percent in this year's budget request from current spending levels. This comes at a time when every considered judgment in my opinion, is telling the committee that we as a country have major problems regarding our technical engineering and science manpower needs.

C. THE NATIONAL SCIENCE BOARD'S PRIORITY SETTING EXERCISE: FIRST-ORDER PRIORITY ONLY TO EDUCATION FOR SCIENTISTS

Dr. Lewis Branscomb, chairman of the National Science Board (NSB), attempted to explain the cutbacks in NSF's science education programs. The NSB, along with the NSF staff, had completed a series of background analyses on science education in anticipation of the Board's discussing the subject in a long-range planning meeting. According to Dr. Branscomb, the first outcome of the Board's deliberations consisted of development of a list of priorities for NSF research support. The first priority was for "research and research level education in our scientific and engineering enterprises." Basically this meant that the Foundation should give top priority to the support of research and to the support of education of scientists at the graduate levels. Later clarifying this statement, Dr. Branscomb distinguished between the importance that NSF should give to graduate education in the sciences, as opposed to its lower ranking of priorities for precollege and undergraduate science education. He said that the Board and the NSF ". . . quite honestly do put a first priority on trying to fix the educational problems that we have in spades at the graduate level and at the college level." The second order priority was to "find a way to get some real leverage on the problem of precollege education . . . in order that there be real change in the country, against a situation which we see as deteriorating." The third priority ". . . was to fund specific projects that require, deserve, and merit Federal support to target particular opportunities in the science education area."

In the ensuing discussion between subcommittee members and Drs. Slaughter and Branscomb, many Members criticized what they apparently perceived as a sham priority-setting exercise. According to Mr. Gregg:

> [The Board said that pre-college science education should be the NSF's second-order priority. But] out of a $1 billion, 172 million budget, if that is a priority and it doesn't get any funds, I guess I have to question whether the priority system is being met.

Mr. Walgren also questioned the ability even of the National Science Board to force the National Science Foundation to implement policies it had previously promulgated:

> Isn't it true that the Board in August of last year recognized the need for a budget commensurate with the mission and program integrity as a fundamental requirement for sustaining a vital science and engineering education effort?

Dr. Branscomb responded: "The Board would have much preferred certainly to keep this function strong and to see some of the program content within it." But it had to set priorities. Even though the Board ranked science education the second order priority of three, apparently the Foundation could not accommodate it within the allocated budget.

D. OTHER CONCERNS EXPRESSED BY MEMBERS AND WITNESSES ABOUT CUTBACKS IN NSF'S SUPPORT FOR SCIENCE EDUCATION

Most of the members present described serious deficiencies in the state of U.S. science and engineering education at all levels--pre-college, where U.S. students' test scores are declining and elementary and secondary school curriculum requirements are being watered down; undergraduate, where college entrance requirements for science preparatory courses and degree requirements for mandatory science courses are being lessened; and graduate, where foreign graduate students, rather than Americans, are coming to dominate graduate science and engineering departments, both in terms of numbers of students and abilities. The Members attributed these deficiencies, in large part, to cutbacks in the NSF support program.

1. Pattern of Historical Declines and Executive Branch Rejection of Congressional Expansion of Science Education Funding

Mr. Walgren noted that, historically, the House Committee on Science and Technology has done repeated studies on science education and has consistently reported legislation to enlarge NSF's science education support programs. He said the bottom line of these efforts is that the National Science Board, the National Science Foundation, and the Office of Management and Budget have consistently given lower priority to science education than the committee has wanted. Mr. Walgren stated that these agencies' actions have forced a ". . . systematic dismantlement of the science education directorate over the past decade."

Congressman Walgren also described his perceptions of the effects of this erosion over time:

> I don't think it is any accident that when you graph the performance of science achievement at the secondary level, it follows almost with a direct correlation the decline of the funding efforts by NSF in precollege science education.

He noted that, in 1960, NSF's education budget was almost 45 percent of the total NSF budget. In 1983, science education expenditures are projected to total only two to three percent of the total NSF budget.

Mr. William Carey, executive officer of the American Association for the Advancement of Science, objected vehemently to the cutbacks in science education. He said: "It is frankly quite tragic to have to stand by while the statutory charge of the Foundation to advance science education is repealed administratively." He also opposed related cuts in the programs of public understanding of science.

Congressman Shamansky charged that the cuts in science education were

> . . . a mindless attack on something which is a continuum . . . . You cannot snip it here and pick it up five, ten, or fifteen years later and expect to have the kind of science and engineering establishment that we must have to survive.

He admonished the committee that Government should try to save budget dollars elsewhere--not by cutting funding for science education. He recommended cutbacks, instead, in tobacco subsidies and attention to minimizing waste, fraud, and abuse in the military budget.

2. Detrimental Effects of Cutbacks on Trained Manpower

This is no time to terminate Federal science education programs, Mr. Shamansky charged, especially since U.S. students are experiencing a further disadvantage in that Federal student loan funds are being cut back. According to Mr. Lundine, the termination in NSF's pre-college science education programs would deny a generation of students adequate science training because of an inadequate number of science teachers. Mr. McCurdy attributed the problems in military manpower and readiness to the shortages in the number of engineers.

E. SERIOUS EFFECTS OF CUTBACKS IN RESEARCH ON SCIENCE EDUCATION AND LEARNING

Several of the witnesses criticized cutbacks in the budget for research on science education. Dr. Robert Glaser, professor at the University of Pittsburgh and president of the National Academy of Education, testified on his experience in directing research on human learning and its relevance to educational technology. He opposed cuts in the research component of the science education program:

> . . . I am rather appalled and frightened by the cuts recommended in science education improvement because I feel so much competition in the scientific literacy of our Nation with respect to the other competition in the world.

Research on human learning is an essential element of scientific and technological literacy, he said. He described critical work on problem-solving and on mathematics and science teaching for young children at the University of Pittsburgh and Carnegie-Mellon which NSF had supported and which he said would suffer irreparably from the termination of NSF support programs in this area.

Congressman Brown said that there was a link between the cuts in science education and the cuts in social sciences and that they would have a detrimental effect on each other:

> There are close connections between the quality of our scientific and technical education and our support for science in general and social science in particular, and much of the quality of teaching is based upon social science research.

He suggested that the proposed NSB Commission recognize this link in its work, especially the importance of educational psychology. In response, NSB member Dr. Friedl said that the Foundation would continue to fund cognitive science [although at a reduced level], which supported research related to improving methods for teaching via memory research.

F. DISCUSSION OF TERMINATION OF THE SCIENCE EDUCATION DIRECTORATE

During the discussions, Foundation staff members tried to answer some of the committee's criticisms. Regarding the termination of the Science Education Directorate, Dr. Slaughter explained that the cutback in funding for science education in the fiscal year 1982 budget and OMB instructions regarding the 1983 budget forced him to cut the Science Education Directorate's staff from 80 to 10 persons. Funding authority for science education comes from a separate appropriations account and funds for research could not be shifted into the account. He said that "Ten persons is hardly an adequate number to staff a directorate." He transferred the remaining 10 persons to a science education office that he created within his own office, and attempted to shift other staff positions in other NSF directorates.

G. THE ISSUE OF SHIFTING RESPONSIBILITY FOR SOME SCIENCE EDUCATION PROGRAMS TO THE STATES

Another important point of discussion related to the balance of Federal versus State responsibilities for science education. In response to a question from Mr. Weber, Dr. Slaughter said that some of the historic Federal responsibilities in science education should be shifted to the States and local governments. There was little discussion at the hearing of the rationale for such a shift to the States and localities. Dr. Wenzlau, who represented a consortium of State colleges, disagreed most vehemently with this proposition. He said:

> Our primary concern is our dismay in the budget proposals for 1983 at the virtual rejection of Federal responsibility for providing resources for scientific education in the United States.

He argued for maintaining a strong Federal role, rather than transferring more responsibilities to the States. His main point was that the legislation which created NSF gave the agency a science education mission on a par with its research support function, and that subsequent congressional action reaffirmed this responsibility:

> In 1950 the legislation which created the Foundation charged it, and I quote: "To develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences." In 1972 Congress again reiterated that dual responsibility in P.L. 92-327. Again I quote: "it authorized and directs NSF to initiate and support basic scientific research potential and science education at all levels." I would like to have had the opportunity to remind Director Slaughter of the dual relationship given that he was talking about there being no sacrificial lambs in this budget. It seems to me that science education is very much a sacrificial lamb in the budget proposed by the Foundation.

Dr. Wenzlau also remarked that the comparative U.S. leadership in science and in some technological areas would dissipate if NSF is allowed to terminate the bulk of its science education programs. He also disagreed with NSF officials who recommended shifting some responsibilities to the States:

> It is patently unreasonable in my view to contemplate State or local responsibility for maintaining national technical and scientific superiority for this country. There are only pitfalls and inefficiencies, not advantages, in even contemplating splitting scientific work into 50 units.

H. TESTIMONY ON THE ALLEGED DEFICIENCIES AND AVOWED BENEFITS OF SPECIFIC NSF SCIENCE EDUCATION PROGRAMS

There was considerable objection to NSF's actions, which appeared to many to signal indiscriminate cutbacks in all education programs except graduate fellowships. It was acknowledged generally during the hearings that the decision to terminate these programs was made originally by the Office of Management and Budget. However, the NSF director and others attributed the roots of this decision, in large measure, to dissatisfaction, mainly within the Administration, with the existing NSF programs. Dr. Slaughter testified that the history of NSF's science education budget suffered from a lack of sustained support from "institutions" (OMB and Congress) responsible for funding the NSF--what he labelled a history of "feast and famine" experienced over the last decade. During the last 10 years, he testified, most Administrations decreased the NSF science education budget while the Congress consistently increased it by mandating many new programs which, he said, were designed basically to meet short-term needs, and were not part of a coherent long-term strategy. "Neither Congress nor the Administration," he said, "thought in terms of their effectiveness in addressing the important issues." In fact, he levied considerable criticism against congressional action in this area. He said:

> Past Administrations perhaps have failed to fully comprehend and recognize that their actions on behalf of the Foundation's science education budget, while well intentioned, could have in fact helped to place us in the untenable position where we find ourselves today. It is a position, where frankly, a monotonically decreasing science education budget has been accompanied by an ever increasing number of programs such that more than 25 separately identifiable activities, each of which is a program addressing an important issue. . . were in fact supported at levels far below that which was necessary to make them effective.

Dr. Branscomb said that he did not attribute much meaning to the correlation between a decline in performance in science in secondary schools and cutbacks in funding for science education in the NSF. He said that there were numerous difficulties with NSF programs, which the Board felt would not be overcome "simply by continuation or even a gradual buildup of the same kinds of activities we had going before." He elaborated by saying that he personally felt they were beneficial to those touched by them, but "what I would insist is that very few people were touched by them." He added that he would like to see more money spent in NSF for science education, but not at the expense of NSF's research budget.

1. Need to Increase Programs for High-School Students

Several of the witnesses testified about the quality of the terminated NSF science education programs. Mr. Finnell agreed, to some extent, with the comments that there may have been too many programs, many of which were inadequately funded, or were ineffective "one-shot" summer programs. As an alternative, he recommended that the Foundation focus on increasing the number of secondary school students prepared in mathematics and science to pursue science careers in college. This would require that planners "build upon the base of multi-year programs now in place in junior and senior high schools, not concentrate on one-shot summer program." Dr. Finnell described a successful program along these lines which he directed, using NSF funds. The program is called the Mathematics, Engineering and Science Achievement Program (MESA), at the University of California at Berkeley. It was one of some dozen nationwide programs involving students, local agencies, and institutions which have a stake in science education. He recommended a concerted Federal, State, local, and private sector program costing approximately $750 million for multi-year secondary school and university programs that would increase the number of graduates completing math-based fields of study. This would serve about two million students in grades 8 through 12. According to Finnell, the Nation is now spending only about $40 million on certain coherent programs, which achieve only one-tenth of the desired objectives.

Dr. Wenzlau cited another NSF program as especially benefical, funding for the Center for Precollege Programs, which his university leveraged to generate additional funding by private industry at 2.5 times the initial level. It enrolled and graduated many successful minority students:

> This precollege program . . . [in one year] enrolled 1,000 students, 1,000 students with an annual institutional budget of under $400,000. . . . We have a very, very high college-going rate among students in this program who are largely from minority groups.

Dr. Klein cited as particularly effective the regional science centers for undergraduates.

2. The Value of Summer Institutes for Teachers

Dr. James Rutherford cited, as among the most successful of NSF's science education programs, a summer institute for teachers called the "cooperative school science program." He described it as follows:

> The idea was that the teacher would not necessarily go off to some distant place for a summer institute, but to a nearby college or university for summer training, and that the relationship would be sustained during the academic year so that the university or college faculty would visit the school, work with the teacher there. The teacher would take some courses. And you would build a sustained relationship between the local scientific community and local science teachers. It seems to me that of the variations on summer institutes and teacher training, that was the strongest, because it persisted over time.

3. Values of the CAUSE Program

Dr. Wenzlau cited, as the most successful science education program, the CAUSE project, which provided funding assistance to develop new curricula in undergraduate institutions. This program provided supplementary funds to Ohio Wesleyan University, of which he is president, for programmatic support to implement a new program by faculty and undergraduates after the school had benefitted from a privately donated computer. Dr. Fenster also cited as benefical the "leveraging" effects of the CAUSE program in attracting additional funding.

4. Need for Other Undergraduate Student Support

Dr. Saul Fenster, president of the New Jersey Institute of Technology, spoke for the 353 member institutions of the American Association of State Colleges and Universities. He testified that these institutions have a combined enrollment of over 2.5 million students which "play a major role in our Nation's science effort." His thesis was that the "proposed cuts . . . ultimately will jeopardize our national security and economic well-being by undermining American industry, commerical, and military strength. Among the negative consequences he predicted were: severe reduction in the size of the pool from which future scientists and engineers will be drawn and that ". . . new entrants into the Nation's technical and managerial work force will, in the aggregate, be increasingly underprepared to function effectively. The longer this situation continues, the longer there will be little chance of turning things around.

He also referred the committee to several recent high-level advisory reports on the state of U.S. science education, which described serious shortages in technically trained manpower, owing to deficiencies in science education in the Nation.

I. THE COMMISSION ON PRECOLLEGE EDUCATION IN MATHEMATICS, SCIENCE AND TECHNOLOGY

NSF officials, including the chairman of the National Science Board, explained the rationale for creating the proposed Commission on Precollege Education in Mathematics, Science and Technology. In contrast to most members of the congressional subcommittee and virtually all witnesses, who were extremely skeptical about the Commission, NSF officials placed great hopes in it. NSF director Slaughter testifed:

> I believe that the most important thing I will do during the period that I have the honor and the privilege of serving as the Director of the NSF is to put into place the Commission on Pre-college Education in Mathematics, Science and Technology to help redirect our focus on scientific, mathematical, and technological education.

1. NSF-NSB Explanation of the Need for the Commission

The Board had recommended that the Commission be created to evaluate the needs of precollege science education and to develop an "action plan" in concert with local and national associations to improve the quality of precollege science education. Specifically, according to Dr. Branscomb, the ". . . major goal of the Commission's work will be through the collaboration with professional scientists, engineers, teachers, and others in the country to find out what in fact can be done at the local, State, and national level." Dr. Branscomb said that an initial objective would be to establish a network among interested parties, including professional societies in science and engineering, school boards, science teachers, and business organizations. He hoped that the Commission would produce a consensus that there is public sentiment to improve science and engineering education and to determine an appropriate Federal role to supplement State and local efforts. Mr. Branscomb said that no Federal program would take effect unless it has local school board support and locally-set high standards. He also said that he expected that the Commission would promote scientists and engineers to do more voluntary work with local school districts. Dr. Slaughter added that the Commission ". . . is being established for the purpose of developing an action plan that will produce preliminary results at the end of 6 months, more substantive results at the end of 12 months and a final conclusive set of recommendations and results at the end of 18 months." The members of the Commission had not been named at the time of the hearing. Dr. Slaughter said seven to nine NSF staff members would support the Commission. The NSF had allocated $700,000 of the NSF fiscal year 1982 appropriation for this effort.

2. Skepticism about the Commission

a. The Dimensions of the Problem Are Already Known

Skepticism about the Commission was prevelant at the hearing. Mr. Walgren said that the director was replacing an effective operating division with another commission to do research on an issue whose parameters were already well-known. He frankly doubted the ability of the proposed Commission to solve major science and engineering education problems. Mr. Lundine, encapsulating in large part the views of others, criticized the concept of a Commission:

> . . . I am very disturbed over the idea that the answer to every major problem facing America is to appoint a board or Commission to study it. I mean if there was ever a time when we needed action about things, it seems like it is now.

Congressman Shamansky said that Mr. Branscomb and Dr. Slaughter acquiesced far too easily to Administration efforts to dismantle the science education program and replace it with a commission. He said that the Commission should be supplemental to on-going support efforts. He charged that Dr. Branscomb was "an apologist for accepting" the move. Mr. Lundine objected to total dismantling of the science education program before replacing it: "Why should we throw out all science education programs, both the good and the bad, before you develop a different program?" Congressman Judd Gregg said he doubted that the Commission would generate the anticipated consensus and grassroots support. Similiarly, Mr. Shamansky said: "I want to begin by observing that the assumption that the Commission is going to come up with the consensus is hopeful, charming, and I believe naive."

b. Recommendations that the Commission Should Focus on NSF Support Programs

Mr. Gregg asked whether the Commission might come up with a recommendation that NSF shift funding from some other program to science education. Dr. Slaughter said that the Commission will not define the NSF budget, although it might recommend that some agencies spend more for science education related to their missions, such as the Department of Defense and the Department of Commerce.

According to Dr. Rutherford, the Commission should confine itself to making recommendations about the future dimensions of NSF programs, not to national issues. Basically, he said, the dimensions of the problems affecting precollege science education are well-known already, and no additional debate was warranted. The real problem was the inadequacy of NSF's science education programs--some were overfunded and some were underfunded. In addition, he said that the Commission would duplicate the existing science education efforts of the scientific community which is already involved in volunteer work. He identified several professional organizations which already have action programs underway in this area: the American Association for the Advancement of Science, (AAAS), the National Research Council, (NRC), the the Institute of Electrical and Electronics Engineers (IEEE), the American Physical Society (APS), and the American Chemical Society (ACS). Furthermore, the Commission's advice was never sought:

> So then why not [create instead] a commission or a committee that will simply lay out the strategies and the organization of the National Science Foundation? Why must there be a commission that will go out and try to tell the States--who didn't ask for the advice--and the local school districts--who didn't ask for the advice--and others what they ought to be doing as opposed to a partnership approach.

Mr. Weber suggested that the Commission look at what other departments of Government are doing in the precollege science education area--referring specifically to the Department of Education and the National Institute of Education. He said that, perhaps, NSF should not support the science education area if these other agencies already did an adequate job. Dr. Branscomb replied that the Commission on Precollege Education is well-coordinated with the Department of Education's Commission on Excellence and he did not foresee any duplication between NSF's mission and that of other agencies since the NSF has a unique mission in science education.

The only Member who expressed faith, although reservedly, in the Commission was Mrs. Heckler. She said " . . . in terms of math, science, and technology education, we are crawling toward the crisis instead of leaping to meet the challenge." But nevertheless, she said that the Commission probably would be useful, but that it also should expand its mission to include examination of enlarging tax credits to give schools the equipment they need.

J. OTHER SOLUTIONS PROPOSED TO DEAL WITH SCIENCE EDUCATION PROBLEMS

Several Members asked Dr. Slaughter, Dr. Branscomb, and other witnesses about their views of major solutions to the Nation's science education programs, in an effort to obtain a clearer indication of the agenda for the Commission or action alternatives to it. Among the suggestions were the following.

Mr. Gregg, Dr. Slaughter, and Dr. Rutherford said that science teachers need higher salaries. According to Dr. Slaughter: "I think the number one problem is the question of teaching. I think the best way to energize high school teachers is to pay them a decent salary. We are not doing that throughout the country. This would require that local school boards give more value to education." Dr. Rutherford also said that teachers need more training in their disciplines and that more science teachers need to be produced. As evidence of the magnitude of the problem, he said that the State of Minnesota produced only one physics teacher in two years. "The only lack of consensus is who is going to pay for higher salaries." He proposed, as a solution to the salary problem, that the Commission look at an alternative such as the following: instead of teaching two classes a day of physics and three of some other subject, teachers should be given the option of teaching two classes of physics and use the rest of the time in productive ways in industry.

Dr. Slaughter also commented on the inadequacy of teacher training and recommended that the Government be concerned with and help set some standards for the way in which schools set teacher entry requirements and with teacher preparation. Curriculum development also warranted improvement. According to Dr. Slaughter, ". . . we should make certain that we facilitate and bring to bear the best minds in the development of a curriculum and assist . . . local school districts in addresssing those kinds of problems." Currently, curricula are based on rote learning and memorization, rather than experimentation and there is an absence of opportunities for students to learn through creative experiences. "We also need to see if we can assist in ways in which industry can play an important role, . . . through encouraging the kinds of tax initiatives that allow instruments to be provided for instruction programs in the schools."

Several witnesses recommended that levels of Federal funding for science education meet certain minimums. Dr. Wenzlau recommended that NSF restore funding for science education; said that at least one-third of the NSF budget should be used for science education; and recommended more support for small research projects, instrumentation, and instructional scientific equipment. NSB Chairman Branscomb testified: "I made the statement yesterday in a speech to the [Institute of Electrical and Electronics Engineers] IEEE . . . that I think we ought to spend three-tenths of a percent of our defense budget on engineering education in addition to what we are now doing."

III. BEHAVIORAL AND SOCIAL SCIENCES RESEARCH SUPPORT PROGRAMS

A. OVERVIEW OF CUTS IN BEHAVIORAL AND SOCIAL SCIENCES AND OF NSF PRIORITIES FOR THESE DISCIPLINES

A considerable portion of the hearing was devoted to the topic of funding for behavioral and social sciences. Dr. Slaughter began his presentation on this topic by reviewing activities during the 1982 budget cycle when NSF, responding to congressional and interest group criticism about massive cutbacks in these disciplines, raised its originally requested level of funding $11.2 million, from $21.1 million to $32.3 million. According to Dr. Slaughter:

> . . . [T]he March request on fiscal year 1982 in the behavioral and social sciences totaled $21.1 million, $10.1 million for the social and economic sciences and $11 million for the behavioral sciences.
>
> This committee, the National Science Board, behavioral and social scientists, and physical scientists throughout the country came together in an extraordinary effort to point out and articulate very clearly and strongly the importance of increased support in these areas to the betterment of our country.
>
> The Administration responded. The National Science Board in June addressed the issue in a very direct fashion . . . . The important result . . . was that the Administration determined that in fact increased funding was required for the behavioral and social sciences, and in an unprecedented move a 53 percent increase was added to our budget in midyear . . . so that $21.1 million was increased to $32.3 million prior to the time when fiscal year 1982 began.

But, Dr. Slaughter said, since partial restoration was made in 1982, there was no significant increase requested in the fiscal year 1983 budget request for the behavioral and social sciences. As a result "Our 1983 request shows only a $800,000 increase over the 1982 figure . . . ."

Dr. Ernestine Friedl, a social scientist and a member of the National Science Board, described the Board's efforts to assess funding for the behavioral and social sciences. The Board's work involved first, receiving presentations by noted scientists about the state-of-the-art of the various disciplines involved, and then, assessing the history of funding for behavioral and social sciences in NSF. She said that the Board subsequently developed a policy statement which reaffirmed the importance of NSF's role in supporting the behavioral and social sciences. The document also ". . . stated clearly and unequivocally that we considered this kind of research on a par with other research that was going on in the Foundation and that it was equally valuable for the national welfare with other kinds of research . . . . " At the Board's request, the staff developed an implementation plan based on these guidelines. Dr. Slaughter described this as follows:

> We chose three areas to pursue: maintenance and development of key national data bases, the improvement and the development of research methodologies and techniques, and investigator-initiated projects intended to strengthen the foundations of our understanding of behavioral and social phenomena.

B. CONGRESSIONAL CRITICISM OF CUTS IN NSF RESEARCH SUPPORT PROGRAM FOR THE BEHAVIORAL AND SOCIAL SCIENCES

Despite the restoration of funding made in the 1982 budget, there was considerable congressional criticism of the overall cutbacks between 1981 and 1983 and of NSF's apparent low priority ranking for these research disciplines.

1. According to NSF, the 1982 Cut in Funding Was a Mistake

Mr. Lundine commented that "The social and economic sciences . . . according to my calculations, experienced almost a 50 percent decrease in funding from 1981 to 1983 . . . . Given the fact that the NSF is a basic source of research in the social sciences how can that level of decrease be justified"? Dr. Slaughter responded that the original cutback in the fiscal year 1982 budget, prompted by OMB economizing measures, "was a mistake." "The Administration recognized that midyear and proposed an increase." Dr. Slaughter testified that the funding restoration does not allow NSF to support all "the first-rate research that emanates from [the social and behavioral science research] community, but it is important to recognize that we are making a move back toward providing some restoration of the important funds to do the research that must be accomplished there."

Congressman Vin Weber charged that the increase in funding proposed for behavioral and social sciences for the fiscal year 1983 ". . . was less than the projected inflation rate, coming on top of the fact that was the area that was subjected to the most substantial reductions the last time around." He asked Dr. Slaughter: ". . . are you convinced that the Administration, as [it is] committed to the existence of the Foundation is committed also to the continued existence of that directorate?" Dr. Slaughter responded affirmatively and said he expected that funding for behavioral and social sciences would be increased following the economic recovery expected within a year or two.

2. Need for More Applied Social Science Research

Mr. Lundine said that he had chaired six days of hearings on human factors affecting innovation and productivity, which convinced him that more social science research was needed on the topics of workplace behavior and on interactions between technology and human factors. He also said that "I became convinced that we need to encourage greater university-industry cooperation in social science research . . . . " Dr. Slaughter responded that, if the Foundation received good research proposals in these areas, it would support them.

In its budget justification to the Congress, the Foundation zeroed out funding for applied social science projects. Mr. Lundine was concerned about this move. Dr. Slaughter said that the Foundation had eliminated the separate directorate that supported applied research, but that henceforth applied social research would be supported from the Directorate for Biological, Behavioral and Social Sciences, which in the past supported only basic research in behavioral and social sciences. Comments from among those present indicated that they were not sanguine that applied research proposals would fare well in a peer review situation when competing with the basic research proposals received. Mr. Weber said that his reading of the NSF budget request led him to conclude that NSF was not supporting adequate amounts of research in the areas of economics and productivity. Dr. Slaughter replied that such topics are supported not only by the Biological, Behavioral, and Social Sciences Directorate, but also by the Engineering Directorate and the Scientific, Technological, and International Affairs Directorate.

C. TESTIMONY BY EXPERTS

Testimony also was heard from a panel of outside social scientists, consisting of an economist, Dr. William Baumol, Department of Economics, New York University; a political scientist, Dr. Philip Converse, Professor of Political Science, University of Michigan; and a psychologist, Dr. Charles Kiesler, Binghman Professor of Psychology, Carnegie-Mellon University. All three members of the panel opened their testimony by criticizing the continued cutbacks in funding for the behavioral and social sciences. Dr. Baumol said that despite the fact that some social science funding had been restored, the crisis is not over, especially since the NSF fiscal year 1983 budget for social sciences is still 43 percent less than the 1980 budget. Dr. Converse was pleased that the actions of the House Committee on Science and Technology held the fiscal year 1982 cuts to 50 percent, rather than the 70 percent proposed originally by the Foundation. He added, however, that increases in inflation in 1982 may have forced an actual cut of 70 percent in terms of real dollars.

1. The Disadvantageous Support Picture for Behavioral and Social Research: Economic and National Security Implications

More federally supported social science research is urgently required, Dr. Baumol concluded, to sustain the economic security of the Nation:

> The United States is locked in a life-and-death struggle for its lead in the international marketplace. At stake are our living standards, our quality of life, and our leadership. The issue is heavily a matter of economics and social science.

Dr. Kiesler said that data from a study of federally funded social science by the National Academy of Sciences demonstrated that in comparison with the other sciences, the NSF funds disproportionately fewer grants in the social and behavioral sciences, in relation to the number of proposals submitted, and that the amount of funds awarded in relation to the amount requested is considerably lower in the social sciences. Like Dr. Baumol, he said that this practice undermines the national interest since ". . . there is hardly a single national problem the solutions to which do not demand some understanding of human nature." Dr. Kiesler also remarked that NSF support for the sciences is not adequately balanced, since the social and behavioral sciences customarily receive disproportionately less than other fields. Specifically, behavioral and social sciences receive about 3 percent of the NSF award budget, but 11 percent of the Nation's science and engineering doctorates are in psychology alone. "In the social and behavioral sciences we must be talking in the order of 15 or 16 percent of the Nation's doctorates funded with 3 percent of the money. That in itself does not sound very balanced and well-funded."

Dr. William Baumol, attributed the resistance of some policymakers to social science to several misconceptions. The legitimacy of social science research is still being challenged by the view that social scientists' political values and professional judgments are biased "toward the left and [that they] unanimously champion big government and subversion of the market mechanism. . . ." "But," Dr. Baumol concluded, "this is untrue." He also said that social scientists have been victims of excessive expectations, some of which they themselves helped to foster: "They have produced no instant cure for crime or drug abuse, no painless cure for inflation." He concluded, however, "But [other kinds of] scientists, too, have similar problems. They have found no foolproof way of disposing of nuclear wastes nor any universal cancer cure. Why should one be subject more to criticism than the other?" Social scientists are also subject to constraints on research which do not burden other kinds of scientists, for example, the fact that studying people may change their behavior and the fact that social scientists cannot experiment with human beings in controlled laboratory conditions.

Social scientists also are affected by policymakers' misplaced beliefs that all basic research can have immediate payoffs. But, Dr. Baumol testified, the Foundation's support of some basic social science research has had immediate payoffs. He cited the theory of economic interdependence and achievement of environmental goals which

> . . . has shown how environmental goals can be achieved with minimal social costs and minimal interference with private enterprise. Only cursory examination of the history of the devastating business fluctuations in the 19th and early 20th centuries contrasts markedly with the history since World War II and shows how far we have come, how much society has benefited from basic research in the social sciences.

Dr. Converse cited as the special virtue of NSF-supported basic research programs: " . . . the confrontation of verifiable theories with hard empirical data designed specifically to address them."

2. The Importance of Support for Computerized Databases

Dr. Philip Converse, testified on the issue of NSF support for computerized data networks. He described the Inter-University Consortium, ". . . a large network involving universities and governmental users of social science data," with headquarters at the University of Michigan. The consortium's databases, most of which were supported by NSF, are fundamentally national in scope and are a "national resource" of immense proportions since they were designed by scholars throughout the country and are longitudinal--some have been maintained for over 30 years. Cuts in NSF's social research budget will prevent the updating of large-scale longitudinal databases which have enabled scientists to accumulate data that monitors the U.S. population in a number of complex domains, such as family income dynamics, aspects of the quality of U.S. life, electoral behavior, and time use. Many NSF grantees, working on their own basic research projects, have used the resources of the consortium. In addition, local, State, and Federal agencies also have used the databases for planning and policy formulation. He cited the Congressional Research Service, in the Library of Congress, as the heaviest Federal user. Its unique needs--to assist Congress--require, however, that data be constantly updated.

The databases are so expensive to maintain, Dr. Converse said, that they could not be continued without NSF support, at a minimum level of at least $8 million. It would be difficult to resume updating the databases, if the files were discontinued for any reason or length of time. Should the database cuts be sustained, Dr. Converse said that the United States might end up being among the only key industrialized nations unable to afford to monitor its social and economic processes. He told the committee that researchers' understanding of today's economic dilemmas would be facilitated if the databases had contained information from the depression-era 1930s.

3. Arguments in Favor of Support for Behavioral Research

Dr. Charles Kiesler began his testimony by telling the committee that he recently served as a member of a panel which drafted a report assessing the contributions of social science research to innovation and productivity and that he also was a member of several NSF advisory panels. He testified that there was considerable evidence attesting to the use of basic social-psychological research and behavioral research in industry, in the development of new social institutions, and in the mangement sciences. Most of these contributions were based on procedures developed by the Federal Government during and immediately following World War II. He cited, in particular, personnel selection procedures, survey research methods, and human factors research. According to Dr. Kiesler, the social and psychological sciences are especially related to the management sciences and, he said, most MBA (Master of Business Administration) courses are in the social sciences. The social and psychological sciences can make crucial contributions to solving complex economic and social problems, he said, citing the value of social science information about how the labor force can adjust to such rapidly changing technologies as preventive medicine, office automation, new energy technologies, and energy conservation measures. Dr. Kiesler estimated that the Nation could save 20 to 30 percent of the energy it consumes with appropriate conservation behaviors. He underscored that "Basic research in the social and behavioral sciences plays a more important role in American institutions and industry than it is typically given credit for." There is a certain irony in this fact since much social science information is exported and benefits this Nation's economic competitors. He cited evidence that techniques used in the Japanese steel industry and Japan's superior management practices, involving quality control circles and participative decisionmaking, are based on U.S. notions. He also testified that the United States should be prepared to expect future security and economic threats by the Soviets, who are supporting large amounts of social psychology research on school systems, the work environment, and basic research laboratories. "I suggest," he added, "that the Soviets and the Japanese have discovered something perhaps the United States has yet to discover. Basic research in the social and behavioral sciences ultimately pays off for the society that supports it."

He also testified to the economic savings that result from investments in social science research:

> Dr. Clark Abt, who is head of Abt Associates [a consulting firm], has estimated that for every $7 spent in applied social research, the research that is based upon basic research, $100 in savings has resulted to the U.S. society.

Dr. Kiesler also questioned the executive branch's understanding of the utility of the social sciences. He participated in writing a report at the National Research Council on the contributions of social and behavioral sciences to innovation and productivity, requested by the Office of Science and Technology Policy for use in the annual report on science and technology. But, he said, the report ". . . was dumped . . . . It is not a sympathetic environment."

4. Expansion of the Economic Recovery Tax Act to Include Social Science Research

In response to a question from Mr. Lundine, Dr. Baumol said that he would support extending the tax credit of the Economic Recovery Tax Reform Act to include social science research, since social science research is in accord with the objectives of the act because it enhances productivity. He illustrated the need as follows:

> My phone rings all the time with people from industry asking me to come and give some advice. They may be foolish and they may be mistaken, but at least by their telephone calls they demonstrate that they do not consider economic advice to be worthless.

IV. PROGRAMS FOR WOMEN AND MINORITIES

The topic of women and minorities was discussed by an expert panel consisting of Shelia Pfafflin, District Manager, Human Resources Department, American Telephone and Telegraph Company, and Charles W. Merideth, Chancellor, Atlanta University Center.

A. INTRODUCTION TO FUNDING ISSUES

Congressman Walgren opened the hearing session by underscoring the recent history of congressional action to overcome underparticipation of women and minorities in science, and executive branch cutbacks in funding for these areas. He said that the "Science and Technology Equal Opportunities Act" (P.L. 96-516), part of the NSF Fiscal Year 1981 authorization act, "directed the NSF to support and initiate activities and programs to improve the access to and increase the participation of women and minorities in science and technology." Specifically, the Act declared that:

> . . . [I]t is the policy of the United States to encourage men and women, equally, of all ethnic, racial, and economic backgrounds to acquire skills in science and mathematics, to have equal opportunity in education, training, and employment in scientific and technical fields, and thereby to promote scientific literacy and the full use of the human resources of the Nation in science and technology.

The Act also declares that "The highest quality science over the long-term requires substantial support, from currently available research and education funds for increased participation in science and technology by women and minorities." Among its provisions, the Act mandates increased support for women and minorities, the establishment of specific programs, such as visiting women scientists, and National Research Opportunity Grants (to recent female graduates or women reentering the workforce), and also authorizes NSF to establish a Committee on Equal Opportunities in Science and Technology to suggest appropriate support programs. The Foundation responded to this Act, Mr. Walgren said, by creating two new programs for women: the National Research Opportunity Grants and the Visiting Professorships for Women. "Also, the Minority Research Initiation Program was created, and an existing program, Research Improvement in Minority Institutions, was strengthened." Originally it was planned that the programs, would receive about $9 million. "However," the Congressman noted, ". . . before these programs could be started, they were eliminated in the March 1981 revision of the NSF fiscal year 1982 budget request. . . ." He also said that the women, minorities, and handicapped programs that were in the Science Education Directorate were zeroed out. Only congressional attention and "diligent efforts" of the NSF director led to a restoration of funding to $2.7 million.

Dr. Slaughter said that the NSF was taking ". . . some aggressive steps" to comply with the Act as reflected in NSF's request for support for programs in this area in the fiscal year 1983 budget. Funding of $5.5 million was requested for these programs in the fiscal year 1983. The requested increases were as follows:

Minority research initiation program, (to support young minority researchers), up 47 percent to $2.5 million;

Research improvement and minority institutions program (for historically black colleges and universities), quadrupled in fiscal year 1983 to $2 million; and

Visiting professorships program for women, doubled to $1 million.

Dr. Slaughter also put two other programs in this category:

Minority institutions science improvement project (for two- and four-year undergraduate minority institutions), program and funds transferred to NSF from the Department of Education, funded at the level of $3.3 million; and

Minority students graduate fellowships program (50 new and 90 continuing fellowships), at a total of $1.5 million.

At one point, Dr. Slaughter said: "I would be hesitant to say that additional funds should be applied specifically to the women and minorities programs that we are identifying in 1983."

B. DISCUSSION OF THE FUNDING CUTS FOR WOMEN'S PROGRAMS

Most of the Members and witnesses present were very critical of the level of funding for these programs. Congressman Mervyn M. Dymally said: "You stated there was an increase in funding for minorities and women, but when taken in a larger context they decrease [from $9 million in the revised 1981 plan to $5.5 million]." Dr. Pfafflin testified ". . . there has been an absolute reduction in funding for women's programs. [Funding for] 1982 represents only twenty-five percent of 1981 funding, and 1983 will only be 50 percent." Dr. Slaughter responded that quality is more important than quantity. The 1983 programs ". . . are much better focused and . . . have a much higher probability of making the kinds of contributions that we believe were asked for in the Congress's actions in establishing the Science and Technology Act. . . . "

Congresswoman Heckler was interested particularly in why the NSF did not seek funding for the National Research Opportunity Grants (NROG), mandated by the statute. Dr. Slaughter responded that it was easier to implement the visiting professorship program than the NROG program, and that the women's subcommittee of the Equal Opportunities in Science Committee was studying how to implement the NROG program. However, NSF deputy director Langenburg testified that the committee had not reached a workable consensus on the NROG program, with the implication that it might not ever be implemented as required. Dr. Shelia Pfafflin, chairwoman of the Subcommittee on Women of the NSF Committee on Equal Opportunities in Science and Technology, testified to the serious obstacles to women scientists in academia--obstacles taking the form of denial of access to professional rewards and to tenure. And, in direct contrast to what Dr. Slaughter said, she recommended that the NSF should proceed to fund the National Research Opportunity Grants program that was authorized but never implemented.

Dr. Pfafflin also called for other kinds of congressional action ". . . to achieve full utilization of women in science," including:

- more research support for women starting careers in science;
- attention to the issue of cutbacks in funding for social and behavioral sciences since women are heavily represented in these areas;
- attention to Federal funding for science education programs, where women are also heavily represented; and
- action to restore cuts in student loan programs, since they will affect the development of women scientists.

Mrs. Heckler did not appear convinced about the adequacy or urgency of NSF's commitment, especially to the women's programs. She said:

> . . . We have an enormous resource in the population of women and the minorities [to solve urgent social and technological problems] and we do not really seem to be making the right linkages. I would hope that there would be a development of a sense of urgency within the NSF on this subject, not only in terms of the National Research Opportunity Grants but really on the whole picture because I think we are dealing with fringe issues and not centrally attacking what could be a major resolution of national problems.

The need for Federal funding appeared especially obvious to her since her participation in the National Governors Conference Task Force hearings on high technology convinced her that industry was studiously avoiding a dialogue on the issue of minorities, women, and the handicapped.

Furthermore, evidence of the cost-effectiveness of Federal support for these programs was given at the committee's hearings in Boston and Pittsburgh. This led her to conclude that "most of the NSF programs we have heard about have paid off in the sense of having the beneficiary earn more within a very short span of time in the private sector, and thereupon return more to the Federal Treasury than actually the cost of the programs." Dr. Kreinberg also addressed this issue, saying that "The most promising sources of talent are women and minorities, who make up 60 percent of the population." She justified her assertions of the need for more Federal programs in this area with "success stories" of women who had received funding from the NSF Women in Science program. The program has served 1,500 women at a cost of $4.8 million since it was established in 1976. "The graduates of these programs with combined yearly earnings of $3 million, have already repaid those costs of the program with tax dollars," she added.

Dr. Kreinberg also said that States have not considered the funding of minorities and women as a significant support priority and, therefore, the Federal Government should continue to maintain its view of the national high-priority nature of this area of support. Since NSF has proven to be a successful coodinator of this area in the past, Dr. Kreinberg recommended that it maintain its coverage in the future.

C. TESTIMONY ON PROGRAMS FOR OTHER MINORITIES

Congressman Dymally criticized the discrepancy between need and the adequacy of NSF's minority programs. Questioning Dr. Slaughter he said, ". . . in your program for minority institutions science development programs we seem to observe a decline, and yet you admit at the same time there is a problem with minority students. How do you reconcile your interests in this area yet your decline in emphasis?" Dr. Slaughter answered that: "Both in terms of people who are investing their energies and thoughts in improving our programs oriented toward minorities and women and also in terms of the potential for funding I think there is an increase in our activity."

Charles Merideth, chancellor of Atlanta University, testified that he would ". . . make a strong appeal to this subcommittee to be responsive to the initiatives that are proposed in the 1983 fiscal budget designed to further impact positively the problem of under-representation of minorities in the sciences and mathematics." To buttress his argument that Federal funding had made significant contributions, he gave several examples of the beneficial effects of Federal funding to Atlanta University. These included:

- an increase in scientific productivity as measured by the rate of publications, resulting in the ability to attract better quality faculty and more sophisticated equipment;

- allowing the school to be more competitive in securing funding from non-minority Federal programs; and

- allowing more participation on an equal partnership basis with several major universities, such as with Georgia Institute of Technology in atmospheric and geophysical chemistry.

He also described the activities of the NSF-funded Atlanta regional Resource Center in Science and Engineering, (one of four regional centers, the others being in Puerto Rico, New Mexico, and New York City), which is geared to providing resources and activities for students at three levels: pre-college, college, and graduate school. He proposed that more Federal attention be directed to developing, at the other resource centers, a program similar to the successful Atlanta prototype of a "Saturday Research Academy"--for younger students.

V. PROGRAMS FOR THE HANDICAPPED

Robert W. Mann, Whitaker Professor of Biomedical Engineering, Massachusetts Institute of Technology, testified on the issue of programs for the handicapped.

A. NSF EXPLAINED FUNDING CUTBACKS

NSF's programs for the handicapped were authorized, in part, by the Rehabilitation Act of 1978. There seemed to be agreement among witnesses that, prior to the fiscal year 1983 budget submissions, NSF was the only Federal agency that supported any basic research related to handicapped persons and rehabilitation. According to Dr. Slaughter, prior to the fiscal year 1983, programs for the handicapped were funded as a line-item from the Science and Engineering Education Directorate. They had been reduced over the preceding two years and were zeroed out totally in the 1983 budget. 1/ The NSF director testified that the Foundation

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1/ According to the committee report on the fiscal year 1983 budget:

> The original program [on Science and Technology to Aid the Handicapped] (formerly in the Applied Sciences and Research Applications Directorate), was authorized in FY 1979 for $2 million. In FY 1980, the committee recommended expanding the program and requested an increase of $1 million over the $1.8 million funding requested by the Foundation, to a total of $2.8 million. In 1981, the S and T to Aid the Handicapped Program was located in the Electrical, Computer and Systems subactivity of the Engineering Directorate at a reduced funding level of $1.6 million. The current plan for FY 1982 shows a further decrease to $600,000, and finally zero funding for 1983.

(Source: U.S. Congress. House. Committee on Science and Technology. Authorizing Appropriations to the National Science Foundation [To accompany H.R. 5842], 97th Cong., 2nd Sess. House Report No. 97-485. Apr. 26, 1982. Washington, U.S. Govt. Print. Off., 1982, p. 14.)

would continue to fund handicapped research via the regular programs of other directorates, especially through the Engineering Directorate ". . . largely for doing activities concerned with research on prosthetic devices, equipment to assist the deaf and blind, so that they too can participate more meaningfully in science and technology."

B. CRITICISMS OF CUTBACKS

Serious concern was expressed about the adequacy of these new support patterns. Congressman Dymally said that the handicapped, as a group, are concerned about the elimination of the program which it had been hoped would be permanent. The NSF response indicated that the Foundation probably did not undertake a serious effort in priority determination before deciding to end the program. According to NSF, the cut ". . . was part of that large reduction in the overall National Science Foundation budget in science and engineering education." Research would continue through the research directorates.

Dr. Robert W. Mann began by describing his qualifications to testify on the issue of handicapped research. He has 20 years of experience developing "rehabilitation hardware oriented to benefit amputees, those with motor pathologies, the deaf, the blind, stutterers, and nonverbal children." He was also a member of a National Academy of Sciences-National Research Council committee that focused on this topic. His thesis was that there are a vast number of handicapped people--about 40 million Americans--receiving commensurately large amounts of disability payments totaling about $114 billion in 1977 alone. He disagreed with the move to cut back on handicapped research in NSF and with Dr. Slaughter's testimony that the other research directorates in NSF would fund handicapped research adequately. The major attraction of the previous NSF handicapped research program was its basic research nature:

> [it] stresse[d] long-term research addressing fundamental issues to expand the knowledge base which may ultimately lead to products, treatments, methods of societal and environmental changes of significant benefit to the physically handicapped.

"Elimination of the NSF component," he continued, "leaves a large injurious gap in the support of more venturesome long-range fundamentally-based rehabilitation research." He summarized the differences between NSF's pre-1983 support programs and those of other Federal agencies as follows. The National Institute of Handicapped Research (NIHR), part of the National Institutes of Health, supports about $30 million of handicapped research annually. But "projects tend to be applied research with clearly defined population targets and relatively short-term outcomes." It concentrates on rehabilitation engineering centers and clinical environments. Its programs ". . . cannot begin to address essentially the magnitude of the problems that the handicapped and disabled persons experience." The Veterans Administration (VA) program is funded at only $7 million per year. Dr. Mann testified that the VA effort is targeted to a select population and is applied research. The work focuses on rehabilitative engineering and requires physician approval via VA medical centers.

Dr. Mann said that he disagreed with Dr. Slaughter's contention that handicapped research would be supported adequately, especially by the Engineering Directorate. Engineers are discipline-oriented, thus proposals for multidiscipline research that is oriented toward developing rehabilitative technology will not compete successfully in NSF given its peer review process. He concluded that: "If handicapping disappears as a target in the NSF program, I submit that the support will disappear." In addition, he said that the cutback in funding will have the secondary effect of drying up development of technology, based on research previously supported by NSF, whose development would be funded in part by the Small Business Innovation Research program.

In response to a question raised by Mrs. Heckler, Dr. Mann cited several successful breakthroughs funded by NSF support and promising areas that would go unfunded with the cutback in the NSF support program. Among the list of successes was the "optacon," and optical-tactle converter invented by John Linville for the blind. Among proposals that have already been rejected by NSF are: the causes of muscular tremor, heavily dependent on neurophysiology, and the pathology of the nervous system.

VI. RESEARCH INSTRUMENTATION

Two witnesses spoke to the issue of research instrumentation needs: Dr. William A. Fowler, Institute Professor of Physics, California Institute of Technology, and Robert Scott, director, Office of Financial Systems, Harvard University.

A. THE MAGNITUDE OF THE PROBLEM; NSF'S BUDGET REQUEST FOR FISCAL YEAR 1983

Mr. Walgren established the theme for the discussion and identified some shortcomings in the NSF support program:

> The Foundation has recognized that investment in instrumentation is a high priority item, and this is reflected to some extent in the budget request. However, it is nowhere clear what level of funding would be required to effectively address the real needs, nor are any real initiatives being proposed.

The Foundation requested, for the fiscal year 1983, $95.3 million for research instrumentation. This was an increase of approximately six percent over the fiscal year 1981 funding level. NSF deputy director Langenberg testifed that NSF no longer had a line-item for instrumentation, but that the Foundation planned to increase support for instrumentation 11.5 percent over fiscal year 1982, to a total of $95 million, via research awards. The amount of increase would vary by directorate, from a low of about 4.8 percent in the U.S. Antarctic program to a high of almost 24 percent in the Engineering Directorate. This includes support for both individual investigators and for shared equipment use, including larger research facilities, such as the astronomical laboratories and regional instrumentation facilities. The Foundation, he added, was exploring ways for industry to donate instruments and equipment to research universities in coordination with the award of NSF research grants.

He also acknowledged that there was a larger national problem whose solution would require concerted action outside of NSF, by other Federal agencies, research institutions, State governments, and industry. He said that there is a national consensus regarding the need to update instrumentation in order to maintain U.S. technological supremacy and in order to ensure the maximum productivity for overall private and public investments in research instrumentation. But, this would entail a five-year investment of between $1 to $4 billion--probably at about $2 billion--with expenditures of about $400 million over each of the next five years. He estimated that the Federal Government would have to supply about one-half and the private sector about one-half of the required amount.

In addition to augmenting its funding by 11.5 percent to $95 million, NSF also planned to monitor the status of instrumentation by exploring the development of a system of indicators describing university research laboratories and equipment. Both Dr. Fowler and Dr. Langenberg testified on preliminary results of an NSF survey of university research laboratories and equipment that indicated that in about one-half of U.S. schools, research instrumentation is between 6 and 10 years old and that there is considerable shared use of equipment. Dr. Fowler said that research funding customarily is used to pay salaries, not to buy equipment, and maintenance costs were escalating. He described the results: experimental researchers leave university laboratories for employment in industrial laboratories. The ultimate consequence may be an imbalance in the U.S. competitive position. A cutback in the number of university research laboratories may force upon the Nation a system like that in the Soviet Union, where there are few graduate researcher laboratories and considerable central planning and research direction.

Responding to some of these concerns, Dr. Langenberg said that there was little more that Congress could do to overcome the instrumentation problems, even in the way of encouraging shared use, since mechanisms were already in place. NSF testified that other steps were being taken immediately: the National Academy of Sciences planned to hold a meeting in the spring of 1982 to discuss this issue and the Office of Science and Technology Policy created an interagency working group on university research instrumentation to review and fashion an overall Federal response to the problem. Among the involved agencies are the National Science Foundation, the Department of Agriculture, the Department of Defense, the Department of Energy, the National Aeronautics and Space Administration, and the National Institutes of Health. Dr. Langenberg said that fiscal year 1983 budget requests include funding augmentation for instrumentation as recommended by the group. Only the Department of Defense's dollar request for instrumentation was mentioned--at $30 million.

B. TESTIMONY ON THE NEED FOR MORE ACTION

Most witnesses and Members present were far less sanguine than Dr. Langenberg about how satisfactory these steps were in overcoming the serious instrumentation problems they perceived. Congressman Shamansky said that, recently, he had toured the physics and chemistry laboratories of Ohio State University. He said that there were no significant improvements in the quality of equipment in the laboratories in 35 years and that updating Ohio State University's instruments alone would cost $85 million. He expected other universities to be facing similar problems. What was required, he said, was a national policy on instrumentation, in which the National Science Board, the governing body of the National Science Foundation, would play a critical role.

Mr. Dymally asked whether NSF is making any special efforts to promote industrial support of instrumentation, especially at small colleges and universities. NSF officials said it was not undertaking any special efforts in this area and that industries which responded to tax incentives by contributing to colleges usually contributed to nearby institutions; smaller institutions would benefit if they were within the giving radius. Dr. Slaughter added that most engineers are graduates of State institutions, not major research institutions. Thus it is in the interest of industry to donate to State and local schools.

1. The Need for Better Accountability in NSF about Instrumentation Expenditures

Three members, Congressmen Walgren, Shamansky, and Gregg, expressed serious concerns about accountability: that NSF did not have an adequate mechanism to ensure that researchers purchased the equipment budgeted by NSF in research awards and that, because reseachers did not purchase the equipment intended by the Foundation, they brought the instrumentation crisis upon themselves. A committee staff member's question encapsulated these concerns:

> The question is . . . one of follow-up. Perhaps in the renewal process, would it be possible for the Foundation to evaluate whether or not the instrumentation, as requested in the orginal grant, was actually purchased and then put a requirement in or simply ask if that has occurred.

He said that the General Accounting Office had evaluated the accountability process for research awards, including instrumentation, in the National Institutes of Health and determined that ". . . those institutes do not have a problem in determining whether or not money is actually spent for instrumentation." Dr. Langenberg did not disagree with these comments. However, he said that NSF does not have a mechanism to monitor whether scientists used the money as set forth in a final approved budget, and apparently does not intend to institute such a procedure in the future. He acknowledged that the scientific community may have kept expenditures for instrumentation below what they should have been for a long-term growth strategy for instrumentation. This may have occurred, he said, because today's scientists began their careers during a boom era of continuously increasing funding. The high levels of funding have ended, but the expectations of the past have not. Despite these problems, he said that he would be opposed to earmarking a certain percentage of research funds for instrumentation since needs of different disciplines differ considerably. He had implicit faith, he said, in the judgment of the scientific community: "I would much prefer to gently but persistently urge the scientific community itself to bear more clearly in mind the instrumentation needs and urge those expenditures upward."

2. Financial Incentives are Required

Mr. Robert Scott of Harvard University attributed deficiencies in instrumentation to a lack of adequate capitalization. He suggested, as an alternative, distribution of costs over a period of years and specifically that universities manage their "capital affairs" by following "the industrial analog and. . . [by] consider[ing] these costs as investments which should be financed and then written off over a period of time." He enumerated the benefits of this approach as follows:

> First, costs are assigned to the specific programs which they benefit and individual programs do not subsidize each other. Second, using this approach, universities will be able to plan far more effectively for their equipment needs, since they will be able to acquire equipment on a well-thought out schedule and without particular regard to the level of support which happens to be available in the very short term.

Other steps are required. One would be to change Federal regulations which ". . . specifically prohibit the recovery from federally sponsored research projects of those projects' fair share of interest costs associated with the facilities. The Office of Management and Budget recently proposed a change in this area which would solve the problem for the future and I strongly urge anyone who can to encourage OMB to make that change official." Such a change would eliminate a number of economic disincentives, for instance by encouraging the use of purchased rather than rental space. He also said that since universities are tax-exempt organizations, the equipment which they purchase does not carry investment tax credits, which he urged be made available for equipment use. He also urged steps to encourage providing incentives to private individuals and corporations to make capital equipment and facilities available to universities, including:

> decreasing the limits which now exist on charitable deductions or allowing donors to utilize investment tax credits or depreciation credits on equipment which they plan to donate. . . .
>
> Also if limits which now exist on research and development tax credits for research performed at universities under corporate sponsorship were removed then industry would have increased incentives to support university research.

VII. INTERNATIONAL SCIENTIFIC AND TECHNOLOGICAL ACTIVITIES

The Foundation's international scientific and technological activities are supported by the Scientific, Technological, and International Affairs Directorate. The Foundation proposed to eliminate two subelements in the fiscal year 1983 budget: international scientific organizations and international travel. The subelement in international cooperative programs was retained. The fiscal year 1983 budget request of $9.1 million represented a decrease of 14.2 percent from the fiscal year 1982 spending level.

Expert testimony about NSF's activities planned for the fiscal year 1983 in international science and technology was heard from the panel comprised of Dr. William D. Carey, executive officer of the American Association for the Advancement of Science, and Dr. Thomas F. Malone, foreign secretary of the National Academy of Sciences.

A. CUTBACKS IN INTERNATIONAL TRAVEL GRANTS PROGRAM; NATIONAL SECURITY CURBS ON INTERNATIONAL INFORMATION FLOWS

Mr. Carey emphasized that he felt the Foundation was still remiss since it did not plan to support some critical areas of international science. He cited particularly the fact that travel funds were being cut as an explicit area of support and that, in the future, travel to international scientific meetings will be supported from the regular research budget, with the consequence that requests for funding for international travel will be forced to compete, probably at a disadvantage, with requests for funding of research proposals. Mr. Carey criticized this move as follows:

> What bothers me is that with one hand we sign bilateral cooperative agreements and send delegations abroad to testify to our enthusiasm for scientific intercourse and interaction, and with the other hand we make it very tough for some of our scientists to get from here to there and to participate in the interactive processes of science that are mutually informative and which build the connections between scientific communities from country to country. It is not as though NSF had been running a travel bureau supporting scientific junkets and jetsetters.
>
> . . . [T]o the contrary, this support has been partial. It has been very very selective and it has helped younger people to get into the picture. I think we are being short-sighted in our failure to hold our own. [Cutbacks in] international scientific exchange will cause us to lose influence in the forums of world class science.

Mr. Carey also criticized the tighter controls that the Government planned to impose on science by means of both enlarging coverage of the export control regulations to include scientific communications and by broadening and making more strict the implementation of the President's executive order regarding the classification of information for national security purposes, thereby imposing "prior restraint" on previously open and unclassified federally supported scientific research and its results. Congress, he said, should be given an opportunity to comment on the policy first. Mr. Carey continued:

> As things now stand under existing policies, classification of basic research not clearly related to national security is forbidden. The new executive order would remove that prohibition. In the current policy there is a balancing test specifying that if the need to protect certain information is outweighed by the public's interest in its disclosure, the material should not be classified. This balancing test is thrown out in the executive order that is pending.

Mr. Carey stated that the executive order contains open-ended discretionary powers to classify much scientific information. He said that he doubted whether the security threat posed by release of scientific and technical information is grave enough now to warrant classification. He said that, if the new order is adopted, "much of the normal discourse of science will be silenced." In his opinion, U.S. scientists will take adequate measures, on a voluntary basis, to protect truly sensitive knowledge from getting into the hands of hostile parties.

B. TERMINATION OF FUNDING FOR THE INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS (IIASA)

There was considerable discussion about the Foundation's plan to terminate all funding for the International Institute for Applied Systems Analysis (IIASA), a "think tank," funded by the United States, the Soviet bloc and Western countries, located in Vienna, Austria. Congressman Brown objected that the termination of U.S. funding, which would necessitate U.S. withdrawal from membership in the Institute, ". . . is a deliberate action [of the Administration] aimed at expressing our desire to withdraw any form of cooperative relationship with the U.S.S.R." In response to these criticisms, Dr. Slaughter said that the decision to terminate funding for IIASA occurred originally because the United States could not any longer support both bilateral and multilateral international science programs. The National Science Foundation had asked other Federal agencies to contribute toward the $2 million membership fee, but no other agencies wanted to share the costs of U.S. participation. Subsequently, a decision was made, at a high level in the Reagan Administration, to terminate funding for financial and also for political reasons on the grounds of alleged Soviet spying at the IIASA and because the United States planned not to renew, when they expired in 1982, the major science and technology, energy, and environmental cooperative agreements with the Soviet Union. The Administration made this decision, Dr. Slaughter said, even though the governing board of the IIASA modified the dues structure to lower the amount of dues to be paid by the United States.

Dr. Malone testified that the governing Council of the National Academy of Sciences, which serves to implement U.S. membership in IIASA, objected to the decision to withdraw from IIASA. He testified that the National Academy of Sciences created a committee to analyze the utility and effectiveness of IIASA; the committee's analysis of IIASA allowed him to draw the following conclusions:

- IIASA performed high quality scientific work.

- IIASA was a unique international nongovernmental organization, linking Eastern and Western bloc countries.

- IIASA once may have served as an espionage base, but that was due more to its location than to its institutional make-up.

- A classified panel looked at the documents passed to the Soviets and alleged to have been a security threat to the United States, but it concluded that there was no security threat. Thus, according to Mr. Malone:

> . . . I am personally deeply convinced that, rather than threatening our national security, this institution is a contribution to national and international security.

- It was alleged that the Soviets have an unfair advantage in using Western bloc databases at IIASA, but the procedures used to access the systems can be changed to eliminate the problem.

- IIASA provides a two-way flow of knowledge between East and West, with the West profitting from Soviet cooperation and expertise. Mr. Malone gave the following example:

> [The new director of IIASA] described to us a week ago . . . a problem of modeling the . . . stochastic processes involved in sorting out competitive technologies. He turned to . . . [a Western scientist present] . . ., who had been awarded a MacArthur Fellowship . . . and some of the best minds in this country, and they were not able to crack the problem. It was turned over to Yuri Ermoleff, of the Kiev Institute of Cybernetics. Within days an elegant solution was developed and made available to IIASA. It is now incorporated into their procedures.

The subcommittee heard examples of IIASA studies, in energy demand modeling, which, he said, gave the United States a wealth of information regarding current Soviet energy supplies and energy plans and also identified how energy shortages will engender major technological stresses on the U.S. system. Another example of the utility of an IIASA study was cited, the East-West dialogue on long-term climatic changes associated with the use of fossil fuels around the world resulting in carbon dioxide buildup and possible global warming.

Congressman Brown said that the IIASA might make more [illegible] contribution to relieving international tensions ". . . if the membership of IIASA would be expanded gradually to allow participation by more of the intermediate level countries."

VIII. INTERGOVERNMENTAL PROGRAMS

The National Science Foundation sought budget support for intergovernmental programs at the level of $500,000. This was a major cutback in funding. Congressman Stan Lundine remarked that ". . . the current request for all NSF intergovernmental programs is $500,000. This compares to $5.5 million in fiscal 1981. . . . [The] science for citizens program has gone from $2.1 million to zero and the appropriate technology program has gone from $1 million to zero." As a consequence, the subcommittee sought testimony on the previous experiences with NSF's intergovernmental program.

Governor James B. Hunt, Jr., of North Carolina, was the principal witness to address the issue of intergovernmental science. He objected to the proposed budget cuts and recommended that the intergovernmental programs receive funding totaling at least $5 million in the fiscal year 1983. The fundamental problem at the root of U.S. economic and productivity problems, he testified, is the "failure to translate adequately knowledge gained through research into products and services essential to our economic growth." The Federal Government, though the National Science Foundation, the Office of Science and Technology Policy (OSTP), and other Federal agencies, should be concerned with total support of R and D, not only basic research, and should cooperate in establishing more of a "partnership of government, academia, and industry and State and local governments must play a role in this partnership." The Government should take the following steps, he said, to enhance this relationship:

> The Federal Government should and must maintain a favorable economic environment by controlling inflation and insuring adequate flows of capital at reasonable interest rates.
>
> Second, the Federal Government should devise incentives designed to encourage investment in research and development.
>
> Third, it should support basic research which is relevant to all States and assist groups of States in pursuing common research and development interests.

Governor Hunt describe several NSF-funded science and technology-related State units in North Carolina which helped promote the State's economic growth. The programs were funded via the NSF's State Science, Engineering and Technology Program. Among the initiatives he mentioned were: the North Carolina Board of Science and Technology, the North Carolina School of Science and Mathematics, the North Carolina bio-technology and micro-electronics centers, and a waste management board. These efforts, he said, enlivened the industrial base of North Carolina and resulted in more jobs and a stronger competitive edge overall not only for North Carolina, but for the country as a whole. Because of the demonstrated successes of the NSF intergovernmental program, it should not be cut.

Governor Hunt also testified that more science policy leadership is required at the Federal level since "We can no longer assume that research utilization will take place automatically by some trickle-down theory." More efforts are needed to translate research findings into products and services. Although he acknowledged, in a discussion with Mr. Lundine, that leadership was needed at the State level to make programs like these work, he said that a *sine qua non* of successful programs is national leadership at the highest levels, analogous to the precedents set by high-level Japanese leadership in the high-technology and telecommunications areas. If NSF does not give more attention to this topic, he said, the Congress should give serious consideration to the proposal to create a National Technology Foundation.

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

OFFICE OF THE
DIRECTOR

March 9, 1982

Honorable Doug Walgren
Chairman, Subcommittee on Science,
Research, and Technology
Committee on Science and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Walgren:

This is to request consideration by your Subcommittee to grant some flexibility within the Ocean Drilling Program line item of the National Science Foundation's FY 83 request. I am asking that the Subcommittee consider allowing the Foundation to move forward on implementing the Advanced Ocean Drilling Program up to an additional $2 million for fiscal year 1982. We would, of course, keep the Subcommittee apprised of developments in this activity.

I appreciate your support in this matter.

Sincerely,

John B. Slaughter

John B. Slaughter
Director

cc: Honorable Margaret Heckler

Additional questions for the record with the formal responses of the National Science Foundation.

Regional Instrumentation Facilities

QUESTION: Between FY 1978 and FY 1981, the Foundation established 14 Regional Instrumentation Facilities, making costly instruments accessible to qualified users, many at smaller institutions. Provide a history of the NSF funding for each regional facility.

ANSWER: The support of each facility is shown in the following table.

REGIONAL INSTRUMENTATION FACILITIES
($ in thousands)

INSTITUTION	FY 1978	FY 1979	FY 1980	FY 1981
University of Nebraska	677	429[c]		288[a]
Colorado State University	609	165	210	192
University of Pennsylvania	600	470[c]		324[a]
University of Arizona	413	361	287[b]	
University of South Carolina	529	193	200	209
Johns Hopkins University	620	270[c]		259[a]
Arizona State University		451	572	255
California Institute of Technology		680	409[b]	
University of California-Berkeley		790	336	331
University of Illinois		902		353[a]
Massachusetts Institute of Technology			590	370
University of Minnesota			832	343[d]
Montana State University		789	200	222
Yale University			812[d]	206
Total	3448	5500	4448	3352

[a] For 16 months
[b] For 18 months
[c] For 20 months
[d] For two 12-month increments initiated at beginning and end of same Fiscal Year (Oct 1-Sep 30)

QUESTION: What control does NSF use to insure that funding in this program is limited to instrumentation and related costs?

ANSWER: Funding for Regional Instrumentation Facilities is not limited to instrumentation and related costs. However, facilities were initiated with a large outlay of funds for instrumentation. To ensure the effective provision of a research capability to the user community support is also directed toward personnel, supplies and materials, and other required costs. Yearly reports are required from each facility prior to the award of continuing support. All expenditures for instrumentation must be approved by the Program Officer. Site visits are made at regular intervals and each facility has established operating procedures based on Foundation approval.

QUESTION: The NSF FY 1983 budget request does not identify a specific amount of funding for the regional facilities under the FY 1982 current plan or for FY 1983, but states that the program will be supported by the appropriate research programs in FY 1982 and FY 1983. How much funding does NSF expect to provide for the Regional Instrumentation Facilities in FY 1982 and in FY 1983? How will these levels of funding be determined?

ANSWER: NSF expects to provide approximately $1,325,000 in each of the Fiscal Years 1982 and 1983 for the Regional Instrumentation Facilities. These amounts represent continuing commitments made by the Foundation to the facilities when they were initiated in FY 1978 and FY 1979. The funding will be provided from the research budgets of the relevant directorates in accordance with assignment of responsibility as determined by a detailed scrutiny of the users of each facility. In each fiscal year approximately $85,000 will be furnished by the Directorate for Astronomical, Atmospheric, Earth, and Ocean Sciences (AAEO), $290,000 by the Directorate for Biological, Behavioral, and Social Sciences (BBS), and $950,000 by the Directorate for Mathematical and Physical Sciences (MPS). Proposals for renewed support from the existing facilities and any proposals for new facilities will be considered in competition for regular research funds.

Special Equipment Programs

QUESTION: Describe the focus of the special equipment programs for mathematics, computer research, chemistry, and materials research, giving the discipline involved and the amount of support provided for each discipline in FY 1981.

ANSWER: As stated in the FY 1981 Budget Request, these programs provide support for the acquisition of research equipment intermediate in cost between that normally included in research awards and that available at major laboratories and national user facilities. This type of instrumentation is generally made available for group or departmental use and represents an effective way of sharing modern experimental capabilities. Except for chemistry, which has a formal Chemical Instrumentation program element, equipment awards are administered within other existing program elements. Specific information relating to these equipment programs in different MPS subactivities is as follows:

Mathematical Sciences -- The focus is on the acquisition of computer equipment by groups of researchers whose work has been seriously impeded by a lack of research computing capability. This program is new in FY 1982 at an initial funding level of $700,000. Examples of this type of equipment required are minicomputers and specialized graphics terminals at an anticipated average cost of $70,000 per award.

Computer Research -- This program is a special competition for assistance with the purchase of computer hardware and/or software which is necessary for research but cannot be justified on the basis of any single research project. In FY 1981 ten awards were made at a total cost of $1.0 million. A typical award consists of one or more minicomputers with associated terminal equipment at an average cost of $100,000.

Chemistry -- The Chemical Instrumentation Program provides assistance to chemistry departments in acquiring multiuser instrumentation such as nuclear magnetic resonance spectrometers or mass spectrometers. The level of support for this program in FY 1981 was $4.4 million.

Materials Research -- In FY 1981, the Foundation provided $3.74 million to purchase special equipment for materials research. A portion of these funds was used for multi-user equipment, such as electron microscopes, mechanical test facilities, materials processing and synthesis facilities, and closed-cycle helium liquifaction systems. The remainder was used for specialized equipment such as superconducting magnets; x-ray, neutron, and photon scattering equipment; low field, low frequency SQUID magnetometers; and picosecond lasers.

Equipment Supported By Individual Research Grants

QUESTION: What is the estimated total for equipment support to be provided by individual research grants in FY 1983 and how does this compare with the 1982 amount?

ANSWER: The estimated amount of equipment support to be provided through individual research grants in FY 1982 and FY 1983 is summarized below. The table excludes special programs of Chemical Instrumentation and Biological Instrumentation which are supported through mechanisms other than individual research grants.

(In thousands of dollars)

Program Activity	Estimate FY 1982	Estimate FY 1983	Difference FY 1983/82
Mathematical and Physical Sciences..................	$28,550.0	$31,900.0	$3,350.0
Engineering.................	6,220.0	7,100.0	880.0
Biological, Behavioral, and Social Sciences...........	10,729.7	10,863.6	133.9
Astronomical, Atmospheric, Earth, and Ocean Sciences.	9,750.3	10,636.8	886.5
Ocean Drilling Programs.....	.0	.0	.0
U.S. Antarctic Program......	332.0	398.4	66.4
Scientific, Technological, and International Affairs.	1,426.1	1,799.5	373.4
Subtotal Research and Related Activities.....	$57,008.1	$62,698.3	$5,690.2

Major Equipment and Other Equipment

QUESTION: What is the total amount of the FY 1983 budget request for Major Equipment and Other Equipment for research?

ANSWER: The FY 1983 request for Major Equipment and Other Equipment summarized by the following table.

(Obligations in thousands of dollars)

Program Activity	Major Equipment	Other Equipment & Instrumentation
Research & Related Activities:		
Mathematical and Physical Sciences.	$7,200.0	$37,700.0
Engineering........................	1,300.0	7,100.0
Biological, Behavioral & Social Sciences.........................	.0	16,063.6
Astronomical, Atmospheric, Earth and Ocean Sciences...............	1,681.7	19,249.0
Ocean Drilling Programs............	.0	.0
U.S. Antarctic Program.............	.0	2,198.4
Scientific, Technological, and International Affairs............	.0	1,799.5
Total, Research and Related Activities.................	$10,181.7	$84,110.5

DEFINITIONS

Major Equipment--Applies to a relatively limited number of specific items of specialized research and development equipment, such as accelerators, telescopes, research ships, research aircraft, and the like.

Other Equipment and Instrumentation--Includes R&D equipment other than those items specifically categorized as "Major Equipment." To qualify as equipment, an item must cost at least $300 and have a uselife of at least one year. Items in this category are treated as part of the cost of "Conduct of R&D."

Accountability Procedures in NSF Research Grants

QUESTION: A recent GAO report dealt with expenditures by NIH and NSF. What has been done to address the needs outlined in that report?

ANSWER: Several recommendations were made by the General Accounting Office in its September 30,1981 report entitled "Better Accountability Procedures Needed in NSF and NIH Research Grant Systems". These, and the corresponding Foundation's reply, are as follows:

Recommendation: Renewal proposal progress reports should identify objectives, project direction changes, and output from from the imediately preceding grant.
NSF Reply: The revisd version of "Grants for Scientific Research" responds to this recommendation.

Recommendation: Review of renewal proposals should explicitly request peer review comment on researcher's past performance.
NSF Reply: NSF is asking peer reviewer's to provide such comment.

Recommendation: Peer review summary statements should be included in the action documentation when individual peer reviewers' comments do not provide such information.
NSF Reply: NSF is following this procedure.

Recommendation: Peer review comments should be sent automatically to proposers.
NSF Reply: This is currently being done.

Recommendation: Furnish reviewers of proposals with final technical reports and list of publications of researchers seeking new project funding.
NSF Reply: Lists of recent publications are provided by proposers; final technical reports and publications are sometimes not available at when proposals are prepared.

Recommendation: Program officers should review annual progress reports systematically.
NSF Reply: NSF program officers make such a review when considering annual installments of continuing grants.

Recommendation: Develop specific guidelines about extent to which researchers can change originally stated grant objectives.
NSF Reply: NSF believes that much scientitic flexibility must be given researcher, and is examining how guidance may be improved.

Effect of Section 222 of Economic Recovery Tax Act of 1981

QUESTION: How will Section 222 of the Economic Recovery Tax Act of 1981 affect NSF plans of instrumentation funding support?

ANSWER: Section 222 of the Economic Recovery Act provides incentives to instrumentation manufacturers to help update university research equipment. The National Science Board has authorized the Foundation to explore alternative means of stimulating donations from these manufacturers.

Contacts between the Foundation and some manufacturers indicate that the latter are aware of the Act. It is, however, too early to predict how extensively they will use the benefits because of uncertainties in interpretation of its provisions. A better picture of the full potential of Section 222 for helping alleviate the instrumentation problem will be possible only after regulations are issued by the Treasury Department. The Foundation plans to continue discussions with both research instrument manufacturers and the university research community on the possible applications of this legislation and to examine the implications of final regulations.

In the meantime, regardless of what contribution this tax incentive provision makes, it is clear that the magnitude of the instrumentation deficit makes additional steps necessary. These may range from encouraging greater university sharing in purchasing and using expensive facilities to experimentation with novel means for capitalizing new equipment acquisition with non-Federal funding and to avoiding under-investment in equipment in research project grants.

Because of the importance of modern instrumentation to scientific progress, the Foundation plans to monitor the situation closely and will adapt its programming to meet developing needs.

Michigan State University Cyclotron

QUESTION: What are the construction and research instrumentation and operations costs related to the Michigan State University heavy-ion superconducting cyclotron supported by NSF for FY 1981, FY 1982 and FY 1983?

ANSWER: (National Superconducting Cyclotron Laboratory for Heavy Ion Research)

		PHASE I		PHASE II
		Operations Costs	Research Instrumentation	Construction
FY 81	NSF	$2.4M	$0.1M	---
(Actual)	DOE	---	---	$6.9M
FY 82	NSF	$2.4M	$0.5M	---
(Current Plan)	DOE	---	---	$4.5M
FY 83	NSF	$2.6M	$0.8M	$6.8M
(Request)	DOE	---	---	---

Construction of phase II is being transferred to NSF from DOE starting in FY 83 with $6.8 million requested. The total estimated cost of phase II construction is $33.0 million of which $16.4 million will have been appropriated through DOE. Thus the total funding balance required from NSF will be $16.6 million (including the FY 83 request of $6.8 million). Upon completion the total research instrumentation and operations of this national facility will be approximately $6 million per year.

Coordinated Experimental Computer Research Facilities

QUESTION: Describe briefly the background, status, and funding level of the Coordinated Experimental Research Facilities program in Computer Research and list the locations of the existing facilities.

ANSWER: The Coordinated Experimental Research (CER) program was initiated in FY 1980 in response to the perceived crisis in academic experimental computer science: lack of appropriate facilities for research, exodus of faculty to industrial laboratories, insufficient production of scientifically trained personnel, and a shift of research to theoretical topics. The problems were identified in a series of studies, notably the Feldman Report. At that time, it was the scientific judgment of the community that only three institutions, MIT, Carnegie-Mellon, and Stanford were sufficiently equipped to perform major experimental computer research. Research equipment at other institutions was essentially nonexistent.

The CER program has three objectives: to provide long term support for equipment, maintenance, systems development, and technical staff necessary to conduct experimental research; to encourage quality experimental researchers to choose academic careers; and to increase the production of scientific personnel trained in experimental methods.

It is estimated that there are twenty-five to thirty computer science and engineering groups which could, with adequate facilities, mount a significant experimental program. These groups form the base of academic experimental computer science both in potential contributions to research and in production of qualified and competent computer scientists.

The CER facilities are funded for a period of five years at an average cost of $750,000 per year per institution. The funding level of the CER facilities program and the location of the facilities is as follows:

FY	CER Funding Level	Location of Facility Initiated
80	$ 868,846	U. of Washington, Seattle, WA
81	$3,774,566	Cornell University, Ithaca, NY U. of Illinois, Urbana, IL U. of Wisconsin, Madison, WI Yale U., New Haven, CT
82	$6,950,000	About 5 new facilities initiated.
83	$9,600,000 (planned)	3 or 4 new facilities are to be initiated.

The CER facilities program of the Foundation is coordinated with efforts by DOD agencies, notably DARPA which funds large experimental research programs at MIT, Carnegie-Mellon, Stanford and the University of California at Berkeley.

Science and Technology to Aid the Handicapped

QUESTION: NSF's FY 1983 budget proposes to terminate the program of Science and Technology to Aid the Handicapped. What is the justification for terminating this program?

ANSWER: Research to aid the handicapped is not being terminated. Rather, it is being integrated into the other research programs of the Engineering Directorate and other parts of the Foundation. The decision to make this change was based on the following factors:

- The applied research restructuring of the NSF in March 1981 carried with it a commitment to support applied research activities in all parts of the Foundation. This arrangement for Science and Technology to Aid the Handicapped (STAH) will provide closer coupling of this type of research with opportunities in microelectronics, bioengineering, robotics, and computer applications than might occur as a separate sheltered program.
- It places the research in a broader context from which greater opportunities for innovative projects might evolve and enhance research effectiveness.

QUESTION: What have been the results of this program?

ANSWER: Research results from a three year period are just now being reported and NSF experience suggests a period of assessment is needed before convincing evaluations can be offered. However, there are indications that the STAH program has had useful results. Projects have been supported to investigate the possibility of combining the capability of modern electronics with additional investigations of the communication capability through intact skin. Several levels of application appear feasible. The most basic would be to provide alerts to the deaf as to direction of sounds. At another level, synthetic speech signals might be provided by means of skin stimulations, so that after a period of training, the deaf might be able to understand speech communications.

QUESTION: Will the types of research previously supported under this program still be supported under the Engineering activity? If so, how?

ANSWER: Research associated with technology related to that carried out previously to aid the handicapped will be supported in several bioengineering programs such as Solid Mechanics; Automation, Bioengineering, and Sensing Systems; and other Engineering Directorate Programs. In addition, projects will be supported by programs in our Materials Research Division and in the Biological, Behavioral, and Social Sciences Directorate. Coordination of this diverse support mechanism will be accomplished through an Interdisciplinary Coordination Committee for STAH.

Geotechnical Centrifuge

QUESTION: How much were the overruns for FY 1981 and FY 1982?

ANSWER: Measured in terms of total project costs, comprised of the University of California, Davis and the NASA-Ames components, the increases to the originally executed agreements are best viewed from the following summary table. This funding schedule does not chronologically match actual contract expenditures by NASA whose procedures require escrow deposits in advance of bid announcements.

In FY 1979, additional funds supported a workshop to explore the possiblities of adding dynamic excitation capabilities to meet developing needs in earthquake engineering research.

In Fiscal Years 1980, 1981 and 1982, unexpected mechanical and electrical design complexities arose in adapting the existing centrifuge to the newer use. Prices increased because of this, and to a lesser extent because of associated inflation during the period that the project was in progress. Each change in the project cost was approved by the NSF consultant panel.

Fiscal Year	Originally Planned	Obligated	Increases
1979	$ 449,993	$ 466,576	$ 16,583
1980	450,000	472,635	22,635
1981	450,000	903,150	453,150
1982	150,000	573,722	423,722
Totals	$1,499,993	$2,416,083	$916,090

The total of $2,416,083 is the limit of the current NSB authorization.

QUESTION: What is the estimated overrun, if any, for FY 1983?

ANSWER: None is expected. As of March 1982, only two major elements have yet to be advertised for bid. They are: Electrical Power and Control and Barrier Wall and Architectural Modifications costing $150,000 and $300,000, respectively.

It should be noted that centrifuges of this size and capacity are uncommon and present unusual difficulties in both engineering and cost estimating. Contracts have been let on all the major components of the centrifuge itself. The two remaining support items noted above are more typical of general engineering practice, and thus provide a better historical basis for estimating costs.

QUESTION: If funding is provided for an overrun in FY 1983, when will the centrifuge be ready for operation?

ANSWER: The initial operation of the facility was scheduled for February 1, 1982. This has been rescheduled for September 1, 1982. Experiments by outside users, after start-up and tuning, can begin on January 1, 1983. Any expenditures beyond those scheduled would require approval by the National Science Board and probably rebidding of the items mentioned above. This could defer availability to the community until July 1, 1983. Additionally, because of the shared power supply arrangement, actual construction must be in phase with a scheduled maintenance shut-down of NASA's Vertical Motion Simulator.

Earthquake Engineering

QUESTION: The U.S. Geological Survey is scheduled to operate the large-scale, ground-array earthquake project. NSF's FY 1983 budget request reflects the transfer of funding responsibility for this project to the USGS. Please explain the reasons for this transfer. What problems, if any, are related to the transfer?

ANSWER: In the past, the NSF provided funding and overall management responsibilities and the USGS provided day to day management, technical expertise, and personnel necessary to execute the work. As a result, the operating responsibility was with USGS, but the responsibility for budgeting and planning was with NSF. This split of project responsibilities has caused strain to both agencies and the transfer is intended to eliminate such problems.

The transfer will allow the USGS to integrate the project into its current in-house programs related to the subject, and to execute the project more efficiently and cost-effectively.

Physiology, Cellular and Molecular Biology

QUESTION: The NSF budget for FY 1983 predicts a 14 percent increase in average award size under the PCM program from $55,800 in FY 1982 to $63,000 in FY 1983. It also predicts a decrease in the number of awards from 1,423 in FY 1982 to 1,335 in FY 1983, which represents a decrease in the proposal success rate from 37.5 percent in FY 1982 to 34.2 percent in FY 1983. Explain the reasons for the increase in average award size.

ANSWER: The increase in average award size reflects the general increase in the cost of undertaking research, and specifically for the increasing adoption of recombinant DNA and hybridoma technology necessary in much modern biological research. In addition, special attention is being given to essential equipment needs in research projects. Funding of these items is necessary to maintain a high quality research effort.

QUESTION: Why does NSF expect a decline in the proposal success rate?

ANSWER: Assuming a modest increase in proposals received, the estimated reduction in success rate results from the plan to decrease the number of awards in favor of increasing the average funding level to maintain research productivity.

Information Science & Technology

QUESTION: Three reports and a letter from a group of Nobel laureates, recently have expressed concern about the use of information science in society. Please comment on the Foundation's reaction to the issues raised in the reports and by the letter.

ANSWER: A November 21, 1981, letter to the Foundation and signed by 26 prominent researchers, including several Nobel laureates, noted that "...the budget of the Division of Information Science and Technology of the National Science Foundation is about to be severely downgraded in the fiscal year 1982 and to be held at that level in the years to follow." The letter urges, "...that the program for the Division of Information Science and Technology at the National Science Foundation, with its potential applications in engineering, economics, management, public administration and affairs as well as defense, be not only preserved but strengthened."

The reduction in the Information Science and Technology fiscal year 1982 budget (from $5.9 million in fiscal year 1981 to $5.2 million in fiscal year 1982) was consistent with a resolution of the National Science Board to maintain support across the breadth of disciplins for the social and behavioral sciences. The fiscal year 1983 budget request for information research is maintained at $5.2 million. The effects of these budget reductions are partially off-set by increases in support for research in disciplines such as computer science and electrical engineering.

Infrared Telescope Facility (IRTF)

QUESTION: Have NSF and NASA officials discussed the possibility of providing funding for this facility for FY 1983?

ANSWER: The Foundation has been approached by NASA about possible assumption by NSF of funding responsibility for the IRTF. On January 15, after our FY 1983 budget negotiations had been concluded with the Office of Management and Budget, a discussion took place between the Director of the NSF Division of Astronomical Sciences and NASA staff concerning the possibility that management and partial funding responsibility of the IRTF be transferred to NSF. Our reply to NASA was that the NSF Astronomical Sciences program was already severely constrained and that there was no provision in our FY 1983 budget to Congress for NSF support of IRTF operations. Thus, NSF could not assume the additional costs for the IRTF in FY 1983.

If in the future it becomes necessary for NSF to consider assuming partial or full responsibility for funding the IRTF, the scientific importance of this facility will be weighed against that of all the other astronomical projects we now support. Given the likelihood that the Foundation's budget will continue to be severely constrained, a decision to support the IRTF will almost surely require termmination of support for major instruments at other observatories, or even termination of entire observatories.

QUESTION: What is the status of funding for the Infrared Telescope Facility in FY 1983?

ANSWER: We understand that NASA has made no final decision on support of IRTF in FY 1983. We are strongly encouraging NASA to continue their support because of the importance of this facility for astronomical research and the fact that it is a major asset to the U.S. astronomical community.

Deep Sea Drilling Project - Foreign Contributions

QUESTION: NSF's FY 1983 budget request shows a reduction in the amount of funding to be contributed by foreign countries for the Deep Sea Drilling Project.

a. Which countries are reducing their contributions and by how much?

b. Please explain any changes and the reasons for them.

ANSWER: Contributions to the Deep Sea Drilling Program (DSDP) through the International Phase of Ocean Drilling (IPOD) are programmed to increase from $9 million in FY 1982 to $10 million in FY 1983 -- a contribution of $2 million from each of the five member countries. The apparent decrease in the table at the top of page ODP-I-1 results from the format of the table itself: income from other sources is subtracted from the total project budget to derive the NSF request.

The IPOD countries agreed in principle to support the project at the rate of $2 million each in FY 1982, but differences in national fiscal years and payment schedules will result in actual receipts of only $9 million during U.S. FY 1982, as shown in the current plan.

Negotiations of 1983 renewals of the Memoranda of Understanding (MOU's) are currently underway. MOU's with the United Kingdom, Federal Republic of Germany, and France have been signed; negotiations with Japan will conclude shortly. Approval of the MOU with the USSR is being reviewed as part of the overall examination of U.S.-U.S.S.R. scientific and technical exchanges.

U.S. Antarctic Program (USAP)

QUESTION: The FY 1983 budget requests funding for the design of a new South Pole Station. What are your estimates of the funds required for planning and construction of the new station?

ANSWER: Any estimates made at this time must be tentative. The type of facility and the construction techniques used will be major factors in determining the cost. Present estimates for a replacement facility range from at least $10 million for material and labor for a very simple, relatively short-life station to $30 million for a more sophisticated permanent facility.

QUESTION: What is the time table for completion?

ANSWER: Once a design concept has been selected, it will require 6 to 7 years from final design to occupancy. The present station required 4 years for on-site construction. To this must be added materials procurement and shipping time. The construction season is short--from November through January; there is only one supply ship per year which arrives at McMurdo Station in January. Material must be shipped onward to South Pole by air beginning the following November.

QUESTION: What is your estimate of FY 1983 funding requirements for this project?

ANSWER: The FY 1983 funding is expected to be $250,000 to $300,000.

QUESTION: Are there any feasible alternatives to construction of a new facility?

ANSWER: No. To maintain a manned year-round station at South Pole in accordance with United States Antarctic policy, reaffirmed by the President in his memorandum of February 5, 1982, the replacement of the existing station is required. This replacement is necessary because of the overburden on the present structures from accumulated drifted snow. During the design phase consideration will be given to maximum reuse of components from the present station.

International Cooperative Scientific Activities

QUESTION: What is the status of the various bilateral agreements between the U.S. and other countries for international scientific and technological activities?

ANSWER: The NSF Division of International Programs manages or shares management of bilateral agreements or similar formal arrangements for scientific cooperation between the United States and 31 countries. Both U.S. and foreign scientists are involved in planning and carrying out research, seminars or symposia, and scientific visits. The activities prominently feature sharing of costs as well as technical responsibility. U.S. scientists obtain access to foreign expertise and research environments.

Status of NSF-Managed Formal Cooperative Arrangements

Country	I.	II.	III.	IV.	V.	Country	I.	II.	III.	IV.	V.
Argentina	A	G	1977		CSV	Japan	A	G	1981		CSV
Australia	A	G	1978		CSV	Korea	M	N	1976		CSV
Belgium	M	N	1980		CSV	Kuwait	A	N	1980		CSV
Brazil	A	G	1981		CSV	Mexico	A	J	1972		CSV
Bulgaria	M	N	1978		CSV	New Zealand	A	G	1979		CSV
China	A	J	1979		CSV	Pakistan	M	N	1981	F	CSV
Egypt	A	G	1981	S		Poland	A	G	1981	S	CSV
Finland	M	N	1980		CSV	Romania	M	N	1979		CSV
France	M	N	1978		CSV	Saudi Arabia	A	J	1975	S	SV
Germany(FRG)	M	N	1980		CSV	Sweden	L	N	1981		CSV
Greece	M	N	1978		CS	Switzerland	M	N	1978		CSV
Hungary	A	N	1977		CSV	Taiwan	G	A	1981		CSV
India	A	J	1974	F	CSV	U.K.	L	N	1980		S
Israel	A	G	1972	S	C	U.S.S.R.	A	J	1977		CSV
Italy	A	G	1981		CS	Venezuela	A	R	1980		CSV
						Yugoslavia	A	G	1978	S	C

Explanation of symbols:

Column I.: Title of the highest authorizing document. A = agreement or joint communique; M = memorandum of understanding; L = exchange of letters.

Column II.: Level of bilateral arrangement. G = U.S. Government; J = U.S. Government, Joint Commission; N = NSF agency-agency; A = contract with American Institute in Taiwan. R = U.S. Government; ratification incomplete.

Column III.: Most recent signature date.

Column IV.: S = program uses funds other than current NSF appropriation; F = funds include special foreign currency.

Column V.: Typical current activities. C = cooperative science projects; S = seminars or workshops; V = scientific visits, exchange visits, or evaluations.

Intergovernmental Cooperation in Science and Technology

QUESTION: The recent National Governors' Association meeting in Washington, D.C. stressed the importance of intergovernmental cooperation in science and technology. The Foundation's budget request for FY 1983 shows $500,000 for intergovernmental activities for both FY 1982 and FY 1983.

How does this budget level relate to the shift of responsibility to the states and an increased emphasis upon "new federalism," as proposed by the Administration?

ANSWER: With the increasing shift of responsibilities to State and local governments, particularly with the emphasis upon "new federalism," the Foundation is consolidating and capitalizing on the lessons learned from prior operation of the NSF Intergovernmental Programs. Program strategy has been to strengthen the management capacity of State and local governments to address issues with scientific and technical components by making effective use of scientific and technical resources. Projects demonstrated alternative approaches to capacity strengthening in realistic and practical settings. They were and are being systematically assessed for their findings, conclusions, and lessons learned. Many of these projects were institutionalized and are being fully supported by non-Federal monies now that NSF funding has ceased.

The Intergovernmental Programs' unique contribution has been and continues to be to assist State and local governments in understanding how best to strengthen their capacity to secure and use scientific and technical resources. The most cost-effective strategy for accomplishing this purpose is to work cooperatively with public interest associations and other intermediary organizations that represent State and local governments (e.g. National Governors' Association, regional innovation groups). This is the approach currently being implemented by the Intergovernmental Programs and proposed also for the next year. To accomplish these activities, the Foundation has allocated $500,000 for FY 1982 and requested the same amount for FY 1983.

Minority Research Initiation

Question: Describe the status of the Minority Research Initiation program in FY 1983, including the focus of the activity, projected number of grantees, and level of funding requested.

Answer: The Minority Research Initiation (MRI) program, which was established in FY 1981, will continue its basic goal in FY 1983 to support capable minority scientists and engineers at any U.S. college or university who are not currently receiving nor have had any prior Federal research support. Within that general approach, emphasis will be given to supporting quality research proposals from scientist and engineers at historically black colleges and universities following the President's Executive Order directing Federal agencies to increase the ability of these institutions to participate in Federally-sponsored programs. Attention will also be focused on the research needs of eligible scientists and engineers at Native American institutions. Scientific areas eligible for consideration will be idential with those of the research directorates.

The MRI program is requesting $2.5 million for FY 1983. This level of funding will support 29 awards at an average size of $86,000 and a duration of three-years.

Visiting Professorships for Women

Question: How may grants does NSF expect to award in FY 1983 under the Visiting Professorships for Women program?

Answer: In FY 1983 NSF expects to award from 15 to 18 grants under the Visiting Professorships for Women Program. The average amount awarded is expected to be about $60,000.

Two-Year and Four-Year College Research Instrumentation

Question: The FY 1983 budget request shows no funding for the Two-Year and Four-Year College Research Instrumentation for FY 1983. Will the program be continued in FY 1983? What level of funding is estimated for this program for FY 1983? How many proposals are expected in FY 1983? How will they be evaluated?

Answer: The Foundation expects the program to be continued in FY 1983 with funding from the research directorates rather than from a separate budget line for the program. It is estimated that about $2 million will be obligated for the program in FY 1983. Approximately 400 proposals are expected. The program will be operated as it has been since it was begun in March, 1979. Proposals will be sent to the program manager. In the fields of science with the greatest number of proposals (at present, chemistry and biology) assembled committees of about 5 or 6 members, meeting about 3 times a year, usually for two days each session, provide most of the reviews. In fields of science where the number of proposals is less, reviews are obtained by mail. The procedures are similar to those used in research project support programs in biology and other sciences.

Applied Research

QUESTION: During FY 1981, the Foundation carried out a reorganization in which each NSF research activity was given responsibility for support of applied research within the purview of its disciplines.

Please provide an accounting of applied research funding in FY 1982 using all available data.

ANSWER: In October 1981, the Foundation initiated an applied research tracking system which will include all actions taken in FY 1982 and beyond. Upon final action on each proposal, program officers are required to record the estimated fraction of the total effort to be devoted to applied research. This data becomes part of the official award record in the Foundation's Management Information System (MIS). As a part of the system, each NSF Directorate has appointed an applied research coordinator to: (1) provide training to personnel to insure accuracy and reliability of coding and data entry; and (2) serve as the liaison with the NSF Office of Planning and Resources Management, which oversees the preparation of reports on applied research and provides general oversight of the tracking system.

As of mid-March, the Foundation has obligated a total of $392 million for all its programs in FY 1982. Preliminary data from the tracking system shows that slightly over $17 million, 4.3% of the total, supported applied research; $369 million, or 94% of the total, supported basic research. The remaining $6 million, or 1.5%, supported the collection of information and education and training.

Personnel Compensation - Proposal Reviewers, Panelists, and Advisers

Question: The FY 1983 budget shows an increase from $476,000 to $700,000 for compensation of peer reviewers. What is the justification for this increase?

Answer: The amount requested for compensation of proposal reviewers, panelists and advisors is increased by $121,925, from the actual amount obligated in FY 1981 of $478,075 to the $600,000 requested for FY 1982 and FY 1983. These amounts include the compensation of the members of the National Science Board, the Director's Advisory Council and other consultants and peer reviewers.

The increase will fund an additional 4.8 full-time equivalent employment (FTE) workyears. These additional FTE's will permit funding of expert fees previously charged directly to program funds and provide needed flexibility in scheduling meetings of proposal review panels to allow more extensive use of advisors who are not members of panels. Also, the increase will provide for additional panelists and advisors for programs such as Visiting Professorships for Women, Industrial Science and Technological Innovation, and for the Advisory Committee on Equal Opportunities in Science and Technology.

Unobligated Balances

Question: The FY 1983 budget shows an unobligated balance in Program Development and Management of $515,000 from FY 1981. Where did this amount come from?

Answer: The Program Development and Management FY 1981 unobligated balance of $515,037 available for obligation in FY 1982 represents approximately nine-tenths of one percent of the PD&M total budget for FY 1981. It results from unspent balances in most PD&M cost categories, with no single one being in excess of $150,000. As stated in the justification, this balance will be applied to the unfunded additional FY 1982 costs of the October 1981 Federal-wide pay increase.

Personnel Ceilings

Question: What are the total personnel ceilings for the Foundation in FY 1981, FY 1982, and FY 1983? For each directorate, provide the personnel ceilings in FY 1981, FY 1982, and FY 1983?

Answer: The following table displays the staffing for FY 1981, FY 1982 and FY 1983 by activity:

Total Personnel Ceilings
Full-Time Equivalent Employment
FY 1981 - FY 1983

	Actual FY 1981	Current Plan FY 1982	Estimate FY 1983
Mathematical and Physical Sciences	122	136	133
Engineering	94	96	95
Biological, Behavioral, and Social Sciences	161	176	170
Astronomical, Atmospheric, Earth, and Ocean Sciences	140	147	144
Scientific, Technological, and International Affairs	199	177	170
Science and Engineering Education	99	45	11
Executive Management	161	189	185
Central Support Services and Administration	337	335	330
Total	1,313	1,301	1,238

Travel Funds

Question: The FY 1983 budget shows an increase in funding for travel from $839,000 in FY 1981 to $1,240,000 in FY 1982. Aside from increasing costs of travel, what other factors contribute to this increase?

Answer: The FY 1982 Current Plan estimate for travel of Proposal Reviewers, Panelists and Advisors is $1,240,000 compared to $839,815 in FY 1981. Of the increase of $400,185, $200,000 has been added to fund in the Program Development and Management Activity travel costs of non-appointed experts which had previously been charged directly to the program activity utilizing the experts' services. The balance is to partially offset increased costs of fares and per diem.

The FY 1983 estimate of $1,140,000 is $100,000 less than the FY 1982 Current Plan.

Minority Institutions Science Improvement Program

QUESTION: The FY 1983 budget shows a transfer of the Minority Institutions Science Improvement Program from the Department of Education to NSF. What is the likelihood of the transfer occurring before the beginning of FY 1983?

ANSWER: It is unlikely that this program will be transferred to NSF prior to the beginning of FY 1983. The FY 1983 budget request for NSF indicates that this program will remain in the Department of Education in FY 1982 and be considered for transfer to NSF at the beginning of FY 1983, subject to Congressional approval.

QUESTION: If the program is not transferred, what arrangements have been or are being made to insure that administration of this program does not become lost?

ANSWER: If the program is not transferred to NSF in FY 1983, it would remain under the auspices of the Department of Education. The fate of the program would then be determined by officials of the Department of Education and ultimately the Congress. NSF has no information at the present concerning what arrangements have been made or are being made to insure the continued administration of this program.